THE INSTITUTION OF ELECTRICAL ENGINEERS

April 1957

JOURNAL

Volume 3 (New Series) No. 28

VOLUME 3 (NEW SERIES) NUMBER TWENTY-EIGHT APRIL 1957

JOURNAL

OF THE INSTITUTION OF ELECTRICAL ENGINEERS

SAVOY PLACE LONDON W.C.2 *Telephone* TEMPLE BAR 7676 *Telegrams* VOLTAMPERE PHONE LONDON

PUBLISHED MONTHLY PRICE SIX SHILLINGS ANNUAL SUBSCRIPTION THIRTY-FIVE SHILLINGS

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HEADS IN THE SAND

THIS MONTH THE INSTITUTION IS PUBLISHING A document of grave significance—the Report on 'Engineering Education in the Soviet Union'. The Report merits serious study by those concerned with Britain's economic future as well as those connected with her education system.

A Past-President, Sir Arthur Fleming, speaking in 1939 about Russian education, said that if the plans which they had laid down in the early thirties were successful, we should be faced, within the span of half a generation, with a very severe challenge. How right he was.

There is, of course, no question of our importing foreign methods of education; our indigenous growth is suited to the climate of this country, but it can be made even more productive if viewed in the light of experience gained elsewhere. Many features of the Russian system, which are valuable for this purpose, were discussed at the Joint Meeting of the three Institutions on the 25th February, when the Report was presented.

When one has adjusted one's mind to the size of the stream of Russian students undergoing higher technological education—a study of Section 8.4 of the Report suggests that the output of technologists may well exceed 200 000 per annum by 1960—one is struck by the surplus of good candidates claiming entrance to the Technical Institutes. This cannot be due only to the prestige and high rewards of the engineering profession, and one must look to the schools to find even stronger reasons. In the ten-year course between the ages of 7 and 17, the school curriculum is to all intents and purposes of a standard and uniform pattern. Though towards the end of the course there may be some drawing out of innate ability, all students study the same subjects. Surely this avoidance of early specialization, this knitting together of the whole company of students, has advantages beyond those of ensuring the broadest possible general education. At the age of 17, the Russian standard is probably midway between that of our G.C.E. (O) and G.C.E. (A), with the all-important difference that it is not in a narrow group of selected subjects only that the desired standard has been achieved. Compare with this the highly differentiated choice offered to our boy or girl who has passed the G.C.E. (O)—a choice that often has to be made by those out of reach of good advice. Thereafter there is almost complete dichotomy. The classics or history boy is encouraged to turn his back on anything scientific, and the scientist has no time for other than his own specialties. Does this help us to face, and compete in, the new technological age?

Criticism is sometimes levelled at the amount of specialization in the later stages of the Russian course. This specialization is much the same in both the Polytechnic and the specialized Institute, but a proper foundation in the basic sciences is not sacrificed in order to achieve this specialization within a period of 5½ years. If one can say, as the Russians think they can, how many specialists of a particular kind one wants in the next ten years, does it matter if one points the undergraduate's specialization rather sharply, providing that the secondary school education and the early years in the Institute have been broadly and well designed? To develop Russia's vast natural resources, to bring as nearly and as quickly as possible to Western levels their standard of living that until recently recalled our Middle Ages, demands an army of technologists whose specialties can be accurately estimated; but once that phase is over and more flexibility is needed, the Russians are sure that they will be able to expand the basic scientific and engineering content of the course and reduce any undue specialization. Let us therefore not say to the Russians 'You are turning out a graduate who is too specialized', when we are turning out potential undergraduates whose secondary education has been seriously distorted, for vocational reasons.

This separation into two groups of cultures and its effect on the adolescent mind can never be adequately corrected by subsequent injections which are little better than *ad hoc* expedients. Unfortunately, the isolation of the classical subjects has all the weight and force of tradition behind it, and to correct it concerted national effort will be necessary. There is no time to be lost. At the present moment the problem of finding for the schools adequate numbers of science teachers is under close examination; taken together the two problems might well exhibit complementary characteristics which would ease rather than aggravate their solution.

Over-specialization in these dangerous years may have another unfortunate result. In comparing our system with the Russian, it has been noticed that from the age of 7 they take one year less than we do to produce a

(*continued on p. 246*)

*The Third Graham Clark Lecture**

THE PLACE OF ENGINEERING IN UNIVERSITY EDUCATION

SIR IFOR EVANS, D.Lit., *Provost of University College, London*

Sir Ifor Evans speaking in the Institution Lecture Theatre

I DID not expect ever to find myself in this place, addressing these three learned and professional institutions from which the country looks for so much during the next phase in our national development. Indeed, it looks for more than, possibly, at present they are prepared and ready to give. I must state my credentials, or, I fear, the limitation of my credentials. I cannot claim to be a scientist, but for over ten years I have been associated with the leadership of two colleges in the University of London: Queen Mary College, and then University College. During that period I have talked with many scientists, and I have tried to extend the departments of science and particularly the departments of engineering. As a consequence I have, naturally, reflected on the relevant problems.

I propose to consider in this lecture the present situation of engineering in our universities and its prospects for the future, for I confidently believe that the adequate solution of this problem is essential for our national welfare. I realize that my theme could be approached in a more abstract theoretical and even philosophical manner, and I hope that I shall not be contravening the spirit of the Graham Clark Lectureship in exploring the problem from a more topical and practical point of view.

Let me here, though, in this introduction, affirm that a university should be concerned mainly with fundamental disciplines. Each subject in a university, whether it has a vocational or professional background, should be in itself a source of mental training and should, by its own content, be capable of exploration through research towards the territories of new knowledge. In the past, among many of the dreary misunderstandings that have affected the history of engineering in our universities and in other places of higher learning, there has been too often a belief that the study of engineering is solely the study of technical expertness and of a professional practice. I doubt if this was ever true. It is certainly not true to-day. Engineering is a discipline as good as any other and better than some. Engineering, as it is studied in the universities, has taken over a substantial part of classical physics, makes heavy demands upon mathematics, and in its varied manifestations, employs these and other studies to its own purposes.

In saying this I am not suggesting that the universities should be detached from professional vocational studies. Some of the most ancient studies in our universities have been professional and vocational, such as law, medicine and, above all, theology, but the changing needs of the community will mean a changing emphasis in the fundamental studies associated with professions and vocations, and it is our neglect of this concept and various prejudices, to which I will later refer, that has retarded so unhappily the development of engineering in our universities.

As a consequence of all this the first danger is that the necessary development of engineering departments in the universities may have come too late. We have in this, as in other matters, to pay the price of past neglect, and the situation cannot be adjusted overnight by the agitated debates of politicians fluttering like frightened birds in the wind of their own rhetoric. It must be recalled that in the early stages there has been an active social and pedantic antagonism to university engineering studies. Its worst aspect is that intellectual snobbism which has been one of the most deadening and disastrous features of English life. Not everywhere is this dead to-day. Historically the development, as far as engineering in England is concerned, depends on Oxford, Cambridge and London, and the growth has been very different in those three universities.

In the University of London, where engineering studies were established much earlier than at Oxford and Cambridge, this social and pedantic snobbism has existed but only in the early days and then on rare occasions. King's College, London, and University College, London, dispute between them the honour of having had the first Chair of Engineering in England. University College designed from the first to have engineering in its curriculum, and Professor Millington was appointed with the

* The Lecture was delivered before the Institutions of Civil, of Mechanical and of Electrical Engineers, at Savoy Place on the 7th February 1957.

first group of professors in 1827. Unfortunately he resigned in 1828 on the refusal of the Council to guarantee a salary of £400, but he did go on giving occasional lectures. It is true that in the early years there was antagonism between proposals for engineering and the ambitions of other departments. When in 1833 a proposal was made for an Engineering Chair it 'provoked a protest from the Professor of Natural Philosophy, who regarded it as an invasion of his province and a menace to his salary'.[1] At last, in 1841, Vignoles was appointed, and gave the department a reputation with his flat-bottom rails. Five years later, there were added the Chair of Mechanical Engineering and the Chair of Machinery. But all the instruction conducted by these professors was maintained with no real laboratory until A. W. Kennedy became active as professor in 1878. A proposal for a laboratory was approved by more than fifty of the chief engineers in the country, many of whom wrote 'cordial letters expressing a wish to help in its development, and promising valuable assistance'.

Even after consulting fifty leading engineers all that was available for equipment was £350, supplemented by £200 from the Gilchrist Trustees. It is interesting to compare the scale of this support with the concern shown by industry for the universities to-day. It is further typical of the scale of the whole approach that the major items of equipment, a 50-ton testing machine provided from Kennedy's own designs and a small compound steam engine, constituted the main equipment of the laboratory until 1893.[1] Slim and inadequate though were these resources, they represented a beginning. Engineering was not a disregarded subject but an equal partner with other new subjects, or new at least for university study in England—physics, geology, medicine. So in a close and compact society the professors of engineering shared, not only with their scientific colleagues but with humanists and artists, the cross-fertilization of mind with mind which is the basis of civilized communication.

In Cambridge development was different. Not only different from London but very different from Oxford. A claim could be made that the Jacksonian Professors were giving some attention to the subject in Cambridge as early as 1796. The duties of the early Jacksonian Professors, as set out in the will of the founder, were very varied:[2]

> The electors are enjoined that they shall appoint '. . . any such person as they shall in their own proper judgments look upon to be the best qualified by his knowledge in Natural Experimental Philosophy and the practical part thereof, and of Chymistry, to instruct the students in the said University in the said Sciences . . . which Lecturer . . . shall . . . read publicly a course of lectures on Anatomy, Animal Economy, Chymistry, Botany, Agriculture or the Materia Medica at large, with due and proper exhibitions of the subject to be read upon . . together with proper Dissections, Analyses and Experiments . . . as may compose a due series of experimental lectures and such practice as may truly thence result for confirmation of what is known at present, or for making further discoveries in any branch thereof as may best tend to set forth the Glory of Almighty God, and promote the welfare of mankind, by making further progress in the practice of physic or agriculture, and the investigation of the relative properties of various earths, sands, clays, marls and the like to each other, so as they best may answer the growth of useful vegetables therein, and also in a more precise investigation of what is or may hereafter be part of the Materia Medica . . . and here it is my serious request that the said Lecturer will in this Disquisition have an eye more particularly to that *opprobrium medicorum* called the gout . . .'

Apparently gout was included at the end of this list because Mr. Richard Jackson suffered from this dread complaint. Indeed in a codicil to his will he writes:

> In the year 1760, after being ill of the gout, by drinking some beer which proved to be a little stale, it seized my stomach, and although Dr. Ash was employed, . . . it continued for ten weeks, without intermission, by fits indeed, but in the main very bad, till I was at death's door, so that at last he ingenuously said, 'Bath, Buxton, or the grave.' I chose Buxton, and by drinking a small quantity of water at the spring head, in three days' time my pains went gradually quite away.

In this uneasy situation engineering continued until the establishment of the Chair of Mechanism and Applied Mechanics in 1875 with a stipend of £300 per annum. James Stuart, who was appointed, ran a series of workshops which can have had little or no resemblance to a university department. Most of his students were studying other subjects and came to the workshops to learn the use of tools. We are told that 'these "shops" were also partly run as a business establishment in which contracts for public work were undertaken. A time came, however, when Stuart's energies were diverted more to politics, journalism, and promoting university extension lectures, after many years of striving to temper the severity of Cambridge mathematics by showing that it had application to practical affairs'.[3]

We have to look to the election of Stuart's successor, Professor J. A. Ewing (later Sir Alfred Ewing), in 1890, to find the real establishment of engineering studies in Cambridge, half a century too late. Ewing was able to obtain laboratories, lecture-room accommodation and the services of two demonstrators, and the modern era had commenced. As was felt even more severely at Oxford, Ewing was aware of a certain class consciousness about his colleagues in other faculties. He contrived to retain rooms in the old Perse School, which had once been used by students of medieval language and literature and by their reverend professor the learned Dr. Skeat. Ewing's biographer tells us that 'Ewing considered it was time that medieval languages should yield to the more insistent and more clamorous claims of engineering. So, with tact, he made arrangements whereby the library, full of the dust of the dead learning of dead men, was removed to other quarters'.

In dealing thus historically with Cambridge and engineering the present picture must not be forgotten. Cambridge has now developed a great school of university engineering and for close on fifty years nearly ten per cent of the whole undergraduate body has been composed of engineers.

In Oxford things have moved differently. It seems that the social and pedantic snobbery has been stronger there than anywhere else in England. Sir David Pye, when he gave his Presidential Address to The Institution of

Mechanical Engineers in 1952,[4] recalled how when he came from Cambridge to Oxford as a lecturer in engineering he was introduced to a Professor of Latin, 'renowned for the acidity of his speech and the soundness of his Oxford conservatism'. 'The Professor of Latin was a tall man', Sir David said. 'He inclined his head in a formal bow and his only remark to me was that he must confess that he had always "most strenuously opposed the introduction of these mechanical studies into Oxford".' Sir David also recalls a head of an Oxford college where no student dared register for the engineering degree. 'Then', he adds, 'in 1913, we were astonished to receive a registration from the College in question. Vain jubilation! The wrath from heaven, in the shape of the Master of the College, magnificent in full academic robes, was next morning at the doors of the engineering laboratory, demanding that his erring lamb should return to the classical fold. We never saw our potential student again.'

For one reason or another pedantic and social antagonism has persisted longer in Oxford than in either Cambridge or London. The Chair of Engineering Science at Oxford was not instituted until 1907, and it was as late as 1909 that Engineering Science was added as a subject to the Final Honour School of Natural Sciences. Hitherto there had only been a diploma in Engineering and Mining which could be taken by a candidate if he had obtained a B.A. In the first examination in the new School in 1910 there were two entries. All that has militated against engineering in the traditional pattern of education in England concentrates at Oxford. It is difficult on any other grounds to explain the fact that the Department of Engineering Science at Oxford is still not full and that the intake includes a large proportion of men who achieve only Third or Fourth Class Honours. This is no doubt partly due to the system whereby entry to the university is controlled by the individual colleges, in many of which a small department such as that of Engineering Science has no representation. Apart from the problem of entry, nearly all those reading engineering have to spend their first year studying physics or mathematics, under the guidance of a physics or mathematics tutor. This system, of course, predisposes those who have no very strong leaning towards engineering to continue to read physics or mathematics in their second and third years, particularly if they do well in these subjects in their first year. How, under even courageous leadership, can university engineering conditions develop in these circumstances?

If we take the national picture as a whole the situation has improved. Indeed if it could be solved by debates in Parliament or by the issuing of White Papers all our difficulties would have long ago disappeared.

It is dangerous to believe all that one reads in Hansard. If one did one might form an impression that now the technologists in the universities were having everything their own way. Hansard described the recent debate in the House of Lords as a debate on engineering and scientific education. Engineering first and science second! But maybe Hansard was approaching the subject only alphabetically! Lord Cherwell in that debate said, 'Humanistic studies are agreeable, and were very valuable in their day. But they do not really help the country to survive to-day.' Göring is said to have put his hand on his pistol whenever he heard the word 'culture': Lord Cherwell approaches this whenever he hears the word 'humanities'.

What we need to-day is not this competitive attitude, but the approach of Aristotle and Leonardo da Vinci, a knowledge that science, and the study of man in his environment, and of all the arts, contribute to a common whole which we have called 'civilization'. For without civilization, 'survival', on which Lord Cherwell places such emphasis, is uninteresting.

The House of Lords debate on the 21st November 1956 did not penetrate very far into the fundamentals of the problem. It failed to define what, precisely, are the technological needs of this country and to what extent the universities can take a share in meeting them. For a share, and a special and defined share is alone possible to the universities unless their own nature and purpose are to be destroyed. Their Lordships seemed as if they had been aroused to the importance of our technological needs only by the developments during the last decade in Soviet Russia. Lord Simon of Wythenshawe, for instance, produced nightmare figures of the numbers of Russian scientists: we have 7000 engineers and the Russians have 80000 and the number is increasing fast; the Russians have 250000 science teachers and we have about 20000.

Nothing is gained by the counting of heads. Engineers and scientists, to be trained adequately, need properly equipped laboratories: engineers and scientists, to be used properly, need properly equipped industries. We have neither to-day. It is here that the Russian example might be quoted more usefully than in vague comparison of numbers. The Soviet Union rigorously, brutally it may be said, has reduced consumer-goods expenditure to build universities and to make adequate capital investment in industry. She has built new industries while we as a nation living leisurely, indulgently, unwilling to face our national position, are letting many of our industries run down. We are eating into the machine assets of our country. It affects shipping first and most obviously, but actually it is affecting every industry, and the present incidence of taxation makes it inevitable.

We need not only to increase the numbers of engineers, but to make the increase effective we need a new view of national life. We need, not vague comparison with the United States and Soviet Russia, but the definition of our own unique situation and the creation of a national policy. The very able document produced last year by the Committee on Scientific Policy of the Advisory Council on Scientific Manpower, under the Chairmanship of Sir Solly Zuckerman, makes this clear in a way that nowhere appears in the House of Lords debate. The Committee base their conclusion about numbers on an increase in industrial output of 4% per annum in the

next decade. This figure was given to the Committee. Yet even this figure means that the country will deal with itself more strenuously and realistically than in recent years. For the Committee tells us that 'to achieve the postulated rate of growth, we are informed, would require the diversion of consumers' incomes to savings to a greater extent than at present in order to make possible a strong expansion of productive investment and exports. A greater rate of growth than 4 per cent would require correspondingly greater changes of the same kind. The extent and speed at which these economic adjustments can take place will depend upon political, economic and social considerations (both within and outside Britain) which we cannot judge'.[5] Yet clearly, if our economy is to be maintained, more of the total output will have to go abroad, and as the Committee tells us that, despite the increase in the population, no additional numbers will be employed in industry, there will be a greater burden of unemployment than we have known since before the war.

In all the discussion of these problems in recent years I think this 1956 report on 'Scientific and Engineering Manpower in Great Britain' is the most realistic, though I understand that as far as electrical engineering is concerned it is stated that they have underestimated the requirements. Their conclusion is that 'the number of people qualifying each year in science and engineering would need to increase from about 10 000 in 1954–55 to about 20 000 in 1970—an increase of about 100 per cent'. Given the right teaching in the schools, and given adequate funds for the construction of laboratories, this is not an impossible task. As the Committee says:

> If this rate of flow is to materialize, higher education in science and engineering will have to continue to develop at least as vigorously in the second post-war decade as it did in the first. Such a rate of flow also requires that the proportion of each age group which proceeds to a higher education in the sciences (now a little over 1%) will not fall, and may even have to rise, as the post-war increases in births raise the numbers between 18 and 20 in the population. If the proportion were to remain the same as to-day, the absolute increase would be from 8 660 new university students in science and technology in 1955–56 to about 13 000 in 1966–67, in addition to the numbers entering advanced courses at the technical colleges.

The task is not impossible. For instance, at University College, London, the engineers at present represent not more than 8% of the student population. Given the facilities of accommodation, staff and equipment, we could easily increase this number at University College, because we get approximately nine times as many qualified applicants as we have available places. Indeed we have plans already now well advanced for increasing the strength of our Engineering Faculty by 100%. I should like here to pay a tribute to industry, which gave us £350 000 to begin this venture. Whatever may have been true in the past, there is to-day a hopeful combination between the universities and industry. I use University College only as an example. Similar developments are taking place elsewhere.

I return to the consideration I raised earlier, which is indeed the major argument in my whole theme—increase of numbers as an isolated exercise will be useless. It must be accompanied by a change of mind over the major part of our industry, and of the nation's conception of the importance of industry and of technical training for industry.

First we must make our young men and our young women feel a pride in all these studies which are a part of those activities through which man has conducted his only partially completed conquest of the forces of nature, physical and biological. I have always admired the grandeur of the main great entry to the Massachusetts Institute of Technology. It seems a symbol of the greatness of these scientific studies, and down the main corridors are those exhibits which show in visual miniature some of the great conquests of science. I have often compared the majesty of this entry with the ancient, overcrowded departments in which some university engineers in this country so gallantly work. I once asked Chancellor Stratton of Massachusetts Institute of Technology how these exhibits had come about. He told me that 'according to its first charter granted in 1861, the Massachusetts Institute of Technology was established "for the purpose of instituting and maintaining a Society of Arts, a Museum of Arts, and a School of Industrial Science". Thus it comprised three distinct parts. The "School of Industrial Science" survives and has flourished in the form that you observed on the occasion of your visit. The Society of Arts was modelled after the lectures that were so popular in that day in association with such names as Herbert Spencer, Huxley, Helmholtz and the rest. The only vestige here remains in a series of Sunday afternoon popular lectures. The Museum has left to us attics and closets full of old equipment and models, and now reappears in these very interesting exhibits of art and science.'

We seem, intermittently, to have had this conception of projecting science and technology in a magnificent way. The Great Exhibition and the labours of the Prince Consort worked in that direction, and when the Manchester College of Technology was opened in October 1902, it could be praised as the best thing of its kind in the world; indeed two expert gentlemen from Boston, Dr. Meyer and Mr. Edward Atkinson, 'asserted with regard to scientific and textile equipment it is the finest and most comprehensive workshop that they had yet seen'. The building itself was a little non-functional in its splendour: French Renaissance style, built of terra-cotta and brick and 'so ornate', we are told, 'and imposing that it looks more like a palace than a school'.[6] Yet the Manchester College was superb compared with what we were to achieve generally in the early twentieth century.

The failure to project in Great Britain the importance of engineering has arisen, I believe, from the depressed conditions under which university engineering began. The legacy which it leaves us is the difficulty which still remains of recruiting young men into the university engineering departments. There were figures issued

recently to show that some of the provincial universities, after accepting all qualified applicants in engineering, have vacancies, and last year a census showed that at the beginning of the session there were a total of 172 places vacant in the country as a whole. I have inquired of all the universities that then had vacancies, and I am happy to report that the position has much improved. But there still are vacancies. Some of these relate to the inadequacy of the applicants. It is surely distressing to discover that one major university had 174 applicants for 1956–57, out of which it was only able to accept 66, though it had 75 places. This leads to the whole question of science teaching in the schools, a problem in which I cannot enter here, but one which should be of major concern to your Institutions. If we were to remove the oversea university engineering students from a calculation of undergraduate and post-graduate numbers the smallness of the remaining figures of British students would be alarming. For instance, one large college of technology informs me that there has been a considerable increase in the undergraduate intake to the engineering departments for the session 1956–57, but this is due entirely to the inclusion of a large batch of oversea students.

At University College we accept only one in nine of the possible candidates. We have taken steps of our own to see that our facilities are known in the schools. But the general national picture I can only explain, apart from the historical reasons which I have given, by the fact that the great opportunities of this wonderful profession are not known in the schools. Chemistry and physics and mathematics are known because there are masters of those subjects, but there are very few engineering masters. I know that your Institutions are aware of this problem. Contacts have been made with the Public Schools Appointments Bureau, the Headmasters' Conferences, and Conferences of Careers Masters, while The Institution of Electrical Engineers has produced a film called *The Inquiring Mind.* All this is admirable, but may I with all deference say that more remains to be done?

Is there not a public relations task of a major character to be attempted? Could not industry combine with the Institutions and possibly one of our leading public relations specialists to undertake this great task? Have your three great Institutions yet fully realized the role you must play in the future of our country? A new task lies ahead for each of you individually. Not only in the electrical and mechanical spheres, but also in the civil engineering world we are moving into an era of new opportunities and new problems. But in this great national task of public relations you must, I venture to submit, take united action and associate with your efforts the active if slightly smaller specialized bodies. I know that the contacts between the universities and the Institutions are increasing, but they are still not enough. One is reminded that in the Soviet Union, whose activities in these matters our leaders so much admire, the academic leaders in engineering have been given prestige and rewards greater even than those of the leaders of industry.

Then again, there must be a change of mind in the higher direction of firms as to the part that engineers can play in management. If our country is to have a new industrial policy which is, I think, essential for our existence, there will be increasing opportunities for the scientist and engineer to go right through, if he has the right qualities, to the very top. Lord Woolton spoke admirably of this in the House of Lords debate of the 21st November 1956:

> If industry wants to get first-class scientists and engineers into its service, it has to make it perfectly clear to the scientist what can happen to him in the future. The scientist does not want to stay in the laboratory all his days, and just to give advice. He wants to get into a position in which, equally with the finance director or the sales director, he will be able in the board room to influence the policy of the business. I was much encouraged by the observations made by the noble Lord, Lord Weeks, but let us remember that he was speaking of the most successful firms in the country. In the smaller firms there is a great deal of room for further encouragement for the scientists to occupy more important positions than now seem to be open to them.

I am convinced that if you give the right scientists and the right engineers the command of direction you will find a new dynamism in industry itself. Surely Calder Hall, which Sir Edward Appleton has said is 'an engineering rather than a scientific triumph', is an example of that.

I realize that there are a number of different routes to professional status as an engineer. There is full-time or part-time release from industry for study at a technical college sandwiched in with practical instruction. There is the work of the higher schools of technology, and the studies that lead to a diploma in technology and the developments arising from the work of the Hives Council. All these are necessary if we are to reach the target which the Government has placed before us in the next decade.

In addition there is the training for engineers which the universities can supply. The departments of engineering can be greatly expanded without disturbing the balance of the multi-faculty colleges. As I have already mentioned, at University College before we begin our engineering expansions the engineering students represent only 8% of the College as a whole. I think that one type of useful training for engineers is in a multi-faculty college. It has the benefit for students of all faculties that in their clubs and societies they meet those engaged in different and varied disciplines. Further, an engineer's course must not be confined to engineering. He must be able to write—to clients, to local planning authorities and to government committees. Further at University College we have courses in the communication of technical information. Then again an engineer, if he is to make real progress, must know a little of the law, of the law of contract and the planning laws.

Engineering courses at universities should, I am convinced, be broadly based on first principles. Such courses based on fundamentals constitute a full university discipline, and a very exacting one. In Russia we are told that current practice is introduced even at these

early stages. But we should be short-sighted to copy this in the universities and submit to the short-term requirements of industry, instead of the long-term policy of engineering development as a whole. A healthy industry will need educated men, with a knowledge of fundamentals, with a capacity for ideas and with a flexibility of outlook, so that they are capable of putting ideas into effect. This is true of both the technical and managerial sides of industry. The requirements of industry are in no way in conflict with the purposes of a university: indeed at some of the important levels they call out vigorously for a university education.

The real weakness of our university engineering training as a whole lies in the weakness of our post-graduate courses. I realize that something is being done here through the regional advisory councils and the technical colleges. In the universities one or two very fine courses are offered, but their number is still pathetically few. For instance, nuclear development in its application to power is going to be more a task for the engineer than for the physicist. Or at least the physicist will be helpless without the engineer.

We have a long way to go, but our minds are at last awakened to the problem. It would be well for us to remember that the archaic snobbery which has in the past affected university studies in science and engineering has also had detrimental consequences in other aspects of our national life. We may not ever again be a world power, but we can remain a great nation. This we can achieve only if we use all our national resources to take a lead in a new industrial revolution. For such leadership we must revise profoundly our whole approach to science and engineering. We must change our outlook more rapidly than we are doing to-day if we are to succeed.

Ever since the middle of the nineteenth century our education in its higher echelons has been devised to train proconsuls, administrators to colonial peoples, practitioners in amply provided learned professions and men of leisure. In the England that now shapes itself for us we must remember that the imperial function has been modified by us in assisting in the construction of free and independent countries not only in the Commonwealth but in the Colonial Empire, and leisure as a profession will be possible for only a minute minority. We must have a nation ready and alert to exploit its own skill in industry, by scientific and technological achievement, by good business management, by ingenuity in salesmanship; in fact we must concentrate everything upon what is necessary to make us a great industrial nation, a great trading and mercantile nation, a nation of inventors, and of exploiters of new methods. To do this we must see that in our schools and universities we exploit all the skills we possess. On the energy that we put behind the solution of this new situation which faces us will depend whether by 1960 we have a prosperous country or not. At least there will be encouragement from all quarters for the task. One sign may be that you have asked me, once a Professor of English, to discuss these problems.

I recall how Chancellor Stratton, in an article in *Physics Today*[7] describes how Henry Adams was among the 39 million visitors to the Paris Exhibition in 1900 to inaugurate the century of hope:

> He tells of radium, X-rays, and the Branley coherer. For the first time he saw 'frozen air' and the electric furnace. The dynamo impressed him most, and it seemed to Adams that among the thousand symbols of ultimate energy the dynamo was not so human as some, but it was the most expressive. And then in a prophetic paragraph he wrote of the new American: '. . . the child of incalculable coal power, chemical power, electric power and radiating energy, as well as new forces yet undetermined—will be a sort of God compared with any former creation of nature. At the rate of progress since 1800, every American who lives into the year 2000 will know how to control unlimited power. He will think in complexities unimaginable to an earlier mind. He will deal with problems altogether beyond the range of earlier society.'

It was in the same period that Freud was announcing his studies on the unconscious mind.

The advance of the physical sciences has been spectacular, but the study, physical and biological, of man in his environment has made a less certain progress. In their combination lies our hope of civilized life and a recovery from the barbarities of the last half-century. Seen in perspective our problem is to bring an understanding of scientific method into the whole of our education from the school age onwards, not to regard it as an odd, temporary emergency call for engineers as if one were calling for the fire brigade.

I read recently an illuminating passage written by Dr. Julian Huxley:

'I would say that the real problem to-day is not that of linking up a separate field of study called classical culture with modern culture, including scientific thought, but that of introducing the historical approach into all studies. In this way the role of the classics in the development of human thought and feeling becomes clear, but in addition science is seen not merely as a static collection of facts and principles, but as a developing adventure of thought. In other words, both the Humanities and the Sciences could come to be regarded as part of a comprehensive humanism. The history of man is the progressive realization of new possibilities, and this applies both to literature and the arts and to science.'[8]

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ELECTRICAL DEVELOPMENT IN KUWAIT

621.311 (536.5)

Kuwait is a busy, thriving boom-town, and the story of its expansion and increasing prosperity is epitomized in its electricity supply industry. This article, based on the Chairman's Address to the Iraq and Persian Gulf Joint Oversea Group, tells of the struggle which electrical engineers had in meeting the phenomenally increasing demand of the last few years. The author, who is Chief Electrical and Mechanical Engineer for the Government of Kuwait, delivered his address at Basrah on the 25th October 1956.

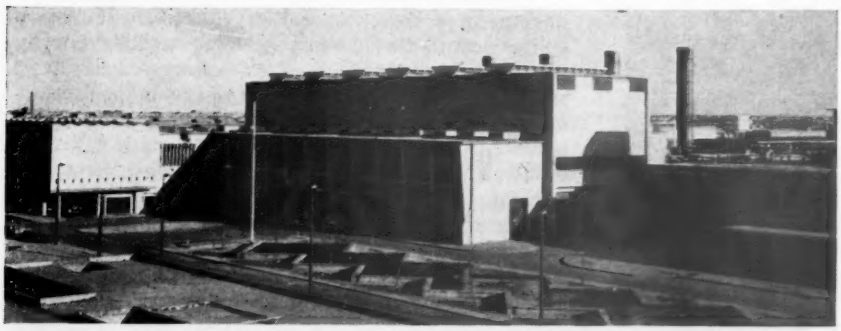
J. D. ADDISON, M.B.E., M.I.MECH.E., MEMBER

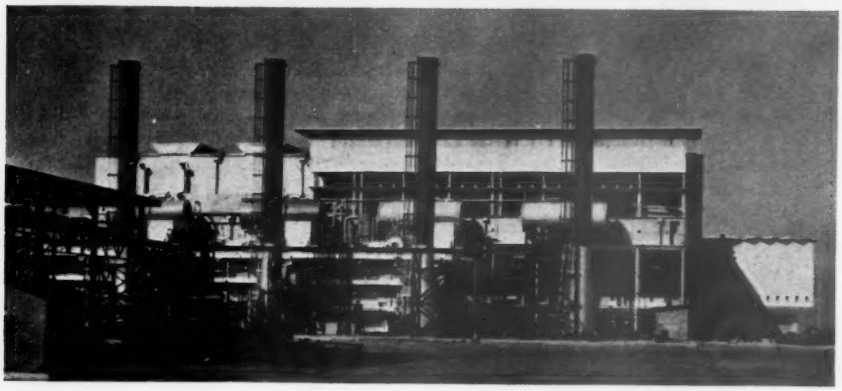
THE Kuwait Electric Co. was formed in 1934 and began operations with two 30 kW d.c. dynamos belt-driven by single-cylinder oil engines. By the end of 1939 the number of consumers had risen to 700 and the peak load to 340 kW. Development ceased during the war, but immediately afterwards the company decided to change over to alternating current and ordered new plant. The Mergab Diesel station was commissioned in 1949 with three 200 kW sets. However, the public demand for electricity soon exceeded the means of the company to meet it; the Ruler of Kuwait bought out the company in July 1951, and decided to organize electricity supply as a nationalized industry.

In November 1951 orders were placed for the boilers and turbo-alternators of a 30 MW steam station, shown in Fig. 1, the fuel to be natural gas from the oilfield. At that time the State income from oil royalties was about £7 million per annum and it was expected to rise to £10 million; thus a 30 MW station appeared to be adequate for the needs of the foreseeable future. However, the subsequent more favourable oil agreement, together with the phenomenal rise in oil production in Kuwait after the Abadan affair, so enhanced the flow of wealth to the State and increased the demand for electricity, particularly for comfort cooling, that a 40 MW extension of the station is now under construction and a further extension is contemplated. Fig. 2*a* illustrates the rise in peak load with growth in oil revenues.

1 *30 MW steam power station*

The control room is on the extreme left. The upper picture shows the front view; the lower shows the view from the rear.

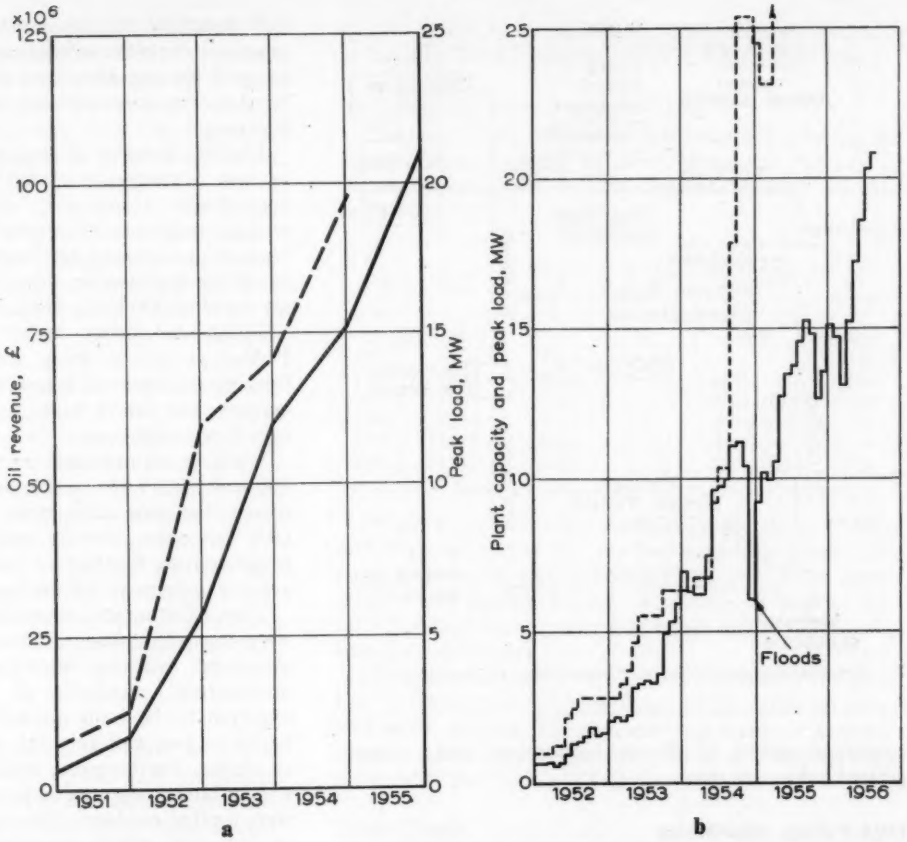




In January 1952 preliminary studies were made of the probable load concentrations in the town. A skeleton 11 kV distribution system was designed with the aid of aerial photographs, on which the routes of proposed roads of the town replanning scheme were superimposed. The network was arranged for supply from the existing Mergab Diesel station, with future extension to the steam station.

The Diesel Generator Stage

From January 1952 until the 21st August 1954, when the first 7·5 MW turbo-alternator was commissioned, we had a continuous struggle to install Diesel generating plant and distribution equipment fast enough to meet the load, and on one occasion load shedding was avoided by running on 55% load a new Diesel generator set on the very first day it ran on load. Voltage regulation on distributors in the early days was well beyond the accepted limits of a modern undertaking, and at peak load



2 *Rise in peak load and plant capacity with growth in oil revenues*

a ———— Peak loads.
— — — Oil revenues.

b ———— Peak loads.
— — — Plant capacity.

the declared voltage of 240 volts dropped to about 80 in many parts of the town. Consumers overcame this by the simple method of removing their 240-volt lamps at peak load and substituting lamps of 110 volts.

When studying the supply problem in January 1952, the authorities decided to standardize the l.v. distribution at 415 line and 240 phase volts, which enabled us to obtain equipment 'off the shelf' in the United Kingdom. Accordingly, we raised the voltage of the old generating plant by field control from 380 to 420 volts, which permitted us to run it in parallel with the plant installed later. Eventually we had fourteen Diesel sets running in parallel in the Mergab station alone.

The Build-Up of Generating-Plant Capacity

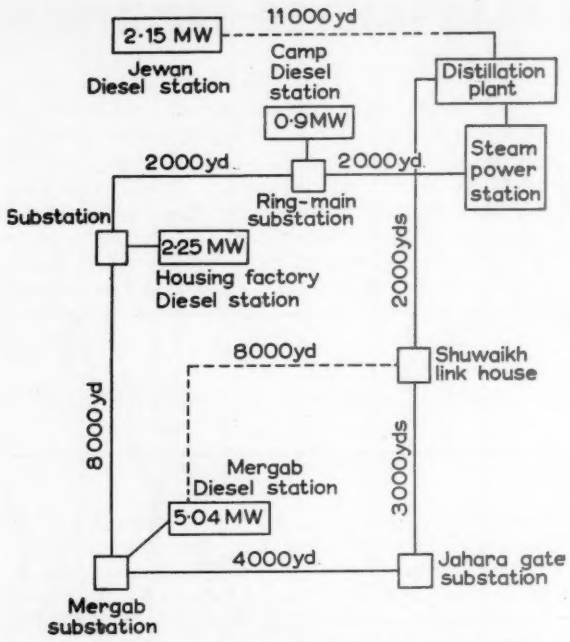
Fig. 2*b* shows the growth of load and the build-up of generating plant to meet it. From 1952 to 1954, skid-mounted 55 kW Diesel generator sets with radiator cooling were employed to cater for load on the fringes of the distribution system, and in a few cases, tail ends of existing networks were isolated from the main system and connected to the small sets.

Initially the installation of larger Diesel generator sets was concentrated in the existing Mergab station, but eventually there were four Diesel stations in widely separated sites having a total installed capacity, when derated for summer temperatures, of 10 340 kW. Three of the stations were operated in parallel on the 11 kV network, as in Fig. 3 (p. 204).

Low-Voltage Distribution

Most of the original overhead distribution was extremely dangerous. Service was provided by pairs of rubber-insulated wires or twin tough-rubber-sheathed cable from the pole and wound round any convenient projection on the house. The line was connected direct to the meter and then to a double-pole metalclad rewireable switch-fuse. The failures arising from sun-cracked insulation in humid and wet weather can better be imagined than described. In many instances distributor extensions consisted of lighting flex from house to house.

New overhead lines were standardized with conductors in vertical formation, and wooden poles were used when they became available. In narrow congested areas, distributors were mounted on wall brackets, or h.s.o.s. cables were fixed on cleats. In crowded, covered bazaars, a conduit distribution system is now employed. Services from overhead lines are either rubber-insulated cable in conduit or h.s.o.s. cable. It is the desire of the Government to have all electric cables underground, and we replace overhead distributors and services as and when



3 *Generating stations and interconnections in August 1954*

conditions permit. In all new development areas, underground cables are used.

High-Voltage Distribution

The 2·2 kV equipment which was ordered by the Kuwait Electric Co. was installed as soon as it arrived, and it was thus possible to improve the voltage and extend the supply network earlier than would have been otherwise possible. The 2·2 kV network was eventually abandoned in October 1955, when the 11 kV network absorbed the load.

In open areas in and around the town, overhead distributors at 11 kV were erected, and temporary substations were energized to meet demands where possible. Much of the temporary overhead system has since been replaced by underground cable and permanent substations. We continue to use overhead lines over open and sparsely populated country and have standardized on wood-pole construction with conductors in horizontal formation similar to that described in B.S. 1320.

A ring-main system of supply for the town was selected to ensure continuity of supply and economy in the use of copper. It will be realized that it is inevitable that some diversion of cables will be required as the new road programme proceeds, and a ring-main system permits such diversions without interruption of supply.

11 kV Substations

The 11 kV metalclad switchgear in the permanent substations is fitted with spring-closing mechanisms. Full switching stations are employed only at network junctions, the other substations of the permanent network being of the ring-main type, each with one feeder circuit-breaker, one feeder isolator, and one or two transformer isolators.

The employment of ring-main substations has given us the advantages of full switching substations at considerably lower cost, with negligible increase of outage times on transformers. Spur feeds to transformers from main switching stations are also used where possible to reduce distribution costs further. All circuit-breakers are rated at 350 MVA rupturing capacity, which will be adequate for safety under all conditions in future. Feeder protection using solid-core summation transformers is employed throughout the system, with overcurrent and earth-fault back-up protection in full switching substations.

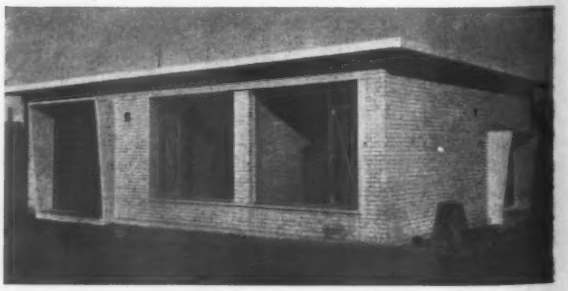
We have standardized on two sizes of transformer—500 and 750 kVA—on the permanent 11 kV system. All recent ring-main substations can accommodate switchgear for either one or two transformers. From the pattern of the build-up of load, it appears that in many areas transformers will be located about 800 yd apart.

The earlier substation buildings, such as that in Fig. 4, were located in streets where town improvement was scheduled, and they were designed to conform to the architectural standards of the edifices which were expected to be built around them. Land values soon began to rise, and sites for substations became difficult to obtain. Furthermore, building costs climbed steeply, so that later designs were made simpler and transformers were located outdoors. Outdoor substations are installed in industrial plants to eliminate building costs. The earlier substations were equipped with separate instrument and relay panels, located in the l.v. switch-rooms, with remote tripping and closing switches in addition to those on the switchgear pedestals. This remote control was provided to reduce anxiety, and to instil confidence in young engineers being trained on the operation of 11 kV switchgear.

33 kV Transmission System

A 33 kV transmission system is now under construction to reinforce the 11 kV supplies at the eastern end of

4 *Typical substation building*



Kuwait town, and to meet demands for supply in rapidly developing housing areas remote from the steam station.

Two 3-core 0·4-inch² oil-filled cables, each 5 miles long, are being laid from the power station at Shuwaikh around the outside of the city wall to a new substation at Subah Gate. Initially each cable will be connected direct to a 15 MVA 33/11 kV transformer. Future extension facilities have been provided to cater for an additional 33 kV feeder, switchgear and transformers.

The first section of the feeder from the power station to Salmieh is underground with two 0·4-inch² oil-filled cables. The remaining section is overhead. Each line will be directly connected to a 15 MVA 33/11 kV transformer at Salmieh substation.

Line protection will be effected by over-current and earth-fault relays at the power station, and at substations reverse-current relays will trip the circuit-breaker on the 11 kV side of the transformer when the 33 kV circuit-breaker opens at the power station. The transformers will have Buchholz and winding-temperature relays, which will trip single-pole fault-throwing switches. All 33 kV substation transformers are of the oil-immersed naturally cooled type with automatic tap-changing gear having 1% steps from 5% to 15%. The 33 kV transmission system is required to be commissioned to meet the anticipated summer load in 1957.

Steam Power Station

The boiler house provides steam for both the power station and a water-distillation plant and comprises seven 80 000 lb/hour water-tube boilers with integral furnaces operating at 210 lb/inch² and 720° F. The boilers are fitted for both gas and oil firing and are erected outdoors with a simple covering over the firing aisle.

There are four pass-out turbines each directly coupled to an 11 kV 7·5 MW alternator. Pass-out steam from the turbines is used in the sea-water evaporation and distillation plants. Cooling water is pumped from the sea through cast-iron pipes across a jetty to a screening chamber and thence by concrete culverts to the stations.

The main 11 kV switchboard is of the horizontal-isolation metalclad type, solenoid operated, with duplicate compound-filled busbars and is rated at 500 MVA.

The control room houses the remote controls for the main and auxiliary switchgear and export metering. It contains a mosaic diagram of the 11 kV feeder circuits and lights for indication of switches tripping in substations. The log desk has telephone connections from the machine hall and substations and a radio-telephone link to outlying substations beyond the town pilot-cable system. The control room has been designed to accommodate the control gear of the extension now being built.

The power station extension will comprise four 125 000 lb/hour boilers operating at 425 lb/inch² and 830° F, and four 10 MW turbo-alternators generating 11 kV. The alternators will be solidly connected to 11/33 kV transformers, and switching will be at 33 kV. The new 33 kV switch-house is in course of construction, and the two parts of the station, A and B, will be linked by two 10 MVA interconnector transformers. Station B is designed for a future extension of two 20 MW sets.

Analysis of Electricity Supply in Kuwait

The table shows that within five years not only has the supply been extended to seven times the number of consumers, but the power supplied to each one has increased fourfold.

Year	Peak load	Number of consumers	Peak load per consumer	Total energy generated	Energy generated per consumer
	kW		kW	kWh	kWh
1951	620	2462	0·25	—	—
1952	1 800	5 067	0·355	4 035 680	796
1953	5 905	8 747	0·675	17 041 028	1 948
1954	12 230	13 148	0·93	41 016 056	3 119
1955	15 295	16 046	0·953	59 945 547	3 736
1956	21 545	18 399	1·171	87 773 090	4 770

At the end of 1951 the population was about 150 000 and thus one person in sixty had electricity supply; the corresponding figures at the end of 1956 were about 250 000 and one in thirteen. Assuming six persons per household, we have connected almost half of the present potential consumers.

It is estimated that in the summer over half of the peak load is taken by comfort cooling and in winter by space and water heating. The average load factor in summer months is 65% and in the winter 52%. The average load factor over the whole of 1955 was 44%.

Future Trends

So many factors affect the consumption of electricity in Kuwait that it is impossible to forecast the growth of load accurately. However, provided the oil revenues continue to increase with world demand for oil, I would suggest that the following trends are likely:

(*a*) The lure of wealth and growth of amenities will attract more people to the town of Kuwait, and there will be a steady rise in the number of potential consumers.

(*b*) The individual purchasing power of the general mass of the population will continue to grow and will open wider markets for electrical appliances, especially for comfort cooling.

(*c*) New office buildings and cinemas will have air-conditioning plants installed as an essential service, and there will be a steady increase in the cooling of shops, hotels and other commercial premises.

(*d*) Until a piped gas supply is available, electricity will be in growing demand for cooking, water heating and space heating.

(*e*) Industrial enterprises are expected to expand, but at a comparatively slow rate.

(*f*) Government projects, such as new hospitals, port installations, flood-lighting of sports stadiums, and implementation of the Shatt al-Arab water scheme, will all add to the demand for electricity.

Industrial Management for Professional Engineers

2. THE MANAGER AND DELEGATION

by A. W. Holmes, B.A., B.Sc.

In his introductory article last month to this series on industrial management Mr. Parsons touched briefly on delegation. Here in the second article Mr. Holmes, a Deputy Works Manager of the Billingham factory of Imperial Chemical Industries, enlarges on this vital subject. Proper delegation is the quintessence of good management. Indeed failure to delegate adequately—albeit because of lack of suitable staff—is a major cause of the overworked state in which many senior executives find themselves to-day. Too much is done by too few 'at the top'. Moreover, with insufficient delegation the talons of frustration will fasten on the minds of ambitious junior staff. The most efficient and successful organizations to-day are often those in which junior executives and professional men are given the maximum responsibility consistent with their training and experience. The partial eclipse of the American Ford Company in the late nineteen-thirties demonstrated clearly the competitive weakness of an industrial organization in which true delegation hardly existed.

Mr. Holmes has written his article with the needs of industry in mind, but there is little in it that does not apply equally to managers in commerce, public utilities, Government establishments, etc. He discusses typical structures of schemes of delegation and outlines some of their problems. He stresses the value of good communication between manager and delegate with both formal meetings and informal discussions. Any successful system of delegation must be founded on confidence—the manager having confidence in the ability of his subordinates and their sense of responsibility in not abusing the authority delegated to them; the subordinate having confidence that decisions taken by him within his own limits of action will not be reversed. Absence of such confidence leads inexorably to the manager becoming overloaded with detail.

THE duties and responsibilities laid on a manager are normally so many that a single man cannot possibly perform them all. The manager must, therefore, carry out his work through the medium of other people. We are well used to the idea of the employment of men as extensions of the manager's arms and legs; to the provision of what is called 'manpower'. In this article we are concerned with the extension of the manager's mind: with the provision of 'brain power'.

In order that use may be made of any extension of an individual, whether in terms of manpower or brain power, it is essential that the extension be given a job to do. Nobody questions this truth in the field of muscular energy but it is not always so well recognized in the matter of brain power. This giving of a job to a mental extension of the manager is referred to as delegation and comprises the transfer of a part of the duty of the manager. It is an essential part of this arrangement that only a part of the duty can be transferred. The responsibility for the proper performance of the duty remains with the manager, the delegate having responsibility to his chief for the performance of the duty laid on him.

Because he must work through the medium of other people the manager will not, in general, deal directly with problems. He must give guidance to those to whom he delegates duties as to the way in which he wishes them to perform those duties. This guidance cannot be through rigid rules but must be in the form of directives setting principles and aims which will enable those to whom the tasks are delegated to make suitable decisions when confronted by problems. The act of taking a decision on behalf of the manager is the key act of the delegate. In taking the decision, the delegate commits the manager to the course of action and builds up, in time, a background which itself orients further progress. The manager must, therefore, clearly indicate to the delegate the aims and direction of policy and must also set limits to the power of the delegate. When a problem is too large for the delegate, it must be brought back to the manager himself so that, if necessary, the whole policy may be realigned. It is of the highest importance that these limits on the power of delegates be clearly set out and understood, for otherwise the whole system may be endangered.

Having decided on policy and laid down the broad lines in directives to his delegates, the manager cannot abdicate and leave everything to them. The manager must so order matters that he is kept informed of what is happening. Only by arranging for a feedback of information can the manager control the situation and maintain his policies in a live and healthy state suited to the circumstances. This feedback requirement sets yet another duty upon each delegate. Not only must he carry out the policy laid down and recognize, and take back to the manager, those problems which are too large for him or fall outside his field of action, but he must

also select and condense for reporting back, so that the manager is adequately informed without being overloaded with detail.

For the system of delegation to work effectively it is essential that there be confidence. First the manager must have confidence in the ability of those to whom he delegates duties to perform those duties within the limits laid down. Secondly he must have confidence in their integrity and honesty in carrying out the policies he has laid down even when they may have other views. Thirdly he must have confidence in their sense of responsibility, which will cause the delegates to refer back to the manager those matters which are too weighty, while dealing with all simpler matters which fall within their allotted scope.

It is equally important that the delegates have confidence. They must have confidence in the stability of the policies they are expected to carry out and in the clarity of purpose of the manager. They must have confidence that, when they exercise their powers within the limits laid down, their decisions will be respected and will not be reversed by higher authority. If this confidence does not exist the system of delegation will fail, for the delegate will refer all matters not having obvious answers to higher authority, which will be overloaded with detail.

The manager himself not only requires confidence in the ability, loyalty and integrity of his delegates, who exercise power on his behalf; he must also have the courage to place himself in the hands of the delegates, for though the manager can delegate his duties, he cannot delegate his responsibility and must in the ultimate analysis answer for the actions of the delegates. Clearly this courage must rest on the foundation of mutual confidence discussed above.

We have thought about the individual relations of the manager and those to whom he delegates his duties. We must now consider the relations of the delegates one to another within the undertaking. This system of relationships is normally referred to as the organization of the undertaking, and it comprises the system of formal subdivisions of fields of interest with which we are familiar in the charts or family trees of organization.

There are two basic ways in which the manager can subdivide his duties for delegation. He may allocate one duty, or a related group of duties, to each delegate, or he may allocate to each delegate a large number of duties but restrict the field over which the duties are exercised. In the first system, which is usually referred to as *functional*, no single delegate is in any sense a miniature of the manager, while in the second, or *line*, system each delegate is a fairly complete miniature of the manager. The problems which face the manager in operating these two systems of delegation are different, though the main problem is always one of co-ordination.

The functional organization has many attractions for the manager as a system of delegation. A specific duty, or group of duties, is delegated to a single individual. This clearly gives the closest possible control and the maximum degree of uniformity in the carrying out of policies within the group of duties concerned. This closeness of control within a narrow field is, however, obtained at the expense of the relations between different groups of duties. The job of maintaining these relations falls on to the manager and cannot well be delegated. Hence problems affecting more than one group of duties are likely to come back to the manager for solution.

The line system, in which each delegate is eventually a miniature of the manager operating in a restricted field with the full range of duties, means that the delegates are each able to maintain the balance between one group of duties and another in their respective fields. The problem here is to see that the balance maintained is similar in all the subdivisions. The manager must, therefore, keep a very close watch on the activities of the delegates to ensure that they are not following divergent lines. This means that the definitions of policy must be more rigid under this type of organization if uniformity of response is to be maintained.

It is normal for an industrial concern to have an organization which combines both functional and line arrangements. Where uniformity of practice is of overriding importance the manager is clearly best served by a system which allows of delegation to a single individual. This is usually the case in matters concerning personnel and in the supply of raw materials and the financial control of the organization. Where production is concerned, however, it is usually preferable to have a unified command over each working unit so that the line system is normally adopted. However where a mixed system is used, the delegates in the line system are not complete miniatures of the manager but only have a restricted range of duties allocated to them.

When a mixed system of organization is employed, the manager is faced with the problems of both types of organization in a limited degree and with a new problem as well. The functional delegates are, by the nature of the work delegated to them, specialists, while the line delegates are essentially general in nature, covering a range of activities. The balance must be maintained between these two types of delegate by the manager himself. This is usually done on the basis that the functional delegates are advisory to the line executives, but this advisory status must carry powers of veto in matters which run counter to the policy laid down by the manager. Whatever the relationship which is fixed between the two sorts of delegates, it must be unambiguous, since it is dangerous and impractical to have two people doing the same job, or each thinking the other is doing it. The delegation must therefore be so defined that this state of affairs does not arise. If it is not so arranged, the manager must expect dissatisfaction and internal squabbles with the consequent loss of efficiency.

Delegation spreads downwards from the manager step by step to the shop-floor supervisors. The whole process being essentially one of successive steps, should the manager by-pass some of these steps for particular purposes? Inasmuch as the system is established to aid the manager, there is no reason why, in some matters, he should not cut out certain steps. However for general

efficiency it is undesirable to do this as a normal practice. There may be circumstances, which would normally be short-lived, when the manager ought to make direct and personal contact with low levels of delegation. Such circumstances are those requiring special emphasis, and the emphasis will arise as much from the abnormality of the manager's direct contact as from anything else. If this emphasis is to remain, the occasions on which by-passing occurs must be few and well chosen, and always the levels of delegation which are by-passed must be informed of the reasons beforehand, if the normal operation of the system is not to be impaired.

So far we have considered the effects and operation of delegation from above, i.e. from the viewpoint of the manager. However, delegation affects those below, particularly the lowest ranks of management—the foremen—and the work-people. The manager works through those to whom he delegates his duties, and he is seen by those at the base of the pyramid of organization largely through the medium of those to whom the duties are delegated. It is desirable that the view obtained should be a coherent and understandable one and this should be borne in mind in arranging the system of delegation, for a scheme which appears very well from above may be very confusing when viewed from below.

To avoid confusion it is desirable that the man on the shop floor should know clearly to whom he is to turn for instructions, advice and the sorting out of difficulties. A system which, at this point, gives the man on the floor what are in effect several distinct bosses, each dealing with a particular field of activity, is liable to cause confusion. Such an arrangement may be quite satisfactory at some of the intermediate levels of management, but it is desirable that the manager's duties, as affecting any particular group of men on the shop floor, be reconcentrated, as far as is practicable, in a single individual. Not all of the manager's duties are relevant to this but those which directly affect the workman should preferably be grouped. This often implies a change in the mode of delegation in the lower ranks with the number of duties increasing and the field in which they are performed diminishing. With this change there goes naturally a tightening of supervision, and the replacement of general directives by rules which allow relatively small scope for interpretation.

One of the major benefits of delegation is rapidity of response. When a decision can be taken on the spot there are obvious advantages as against the delays involved in reference back to higher authority. Waiting time and the frustrations of delay are eliminated. The answer can be clearly seen to be related to the question, which has not had time to change while the answer was being prepared. When the matter has to be passed up and subsequently down again, much of the subtler meanings are lost and the distortions which are liable to occur at each point of transfer can lead to serious errors. The counterbalancing risk of delegation is that the decisions in different parts of the organization will be inconsistent.

Reference was made in the fourth paragraph of this article to the question of feedback of information. This feedback of information on the actions of delegates is essential if the manager is to maintain control. Because of the wide fields covered, much thought and effort have been devoted to devising and elaborating systems of financial and numerical control whereby numerical data are fed back to the manager. This type of feedback is essentially mechanical. It lends itself readily to varying degrees of detail to suit the needs of the different levels of delegation, with a manageably sized summary available for the manager on such a basis as he desires. However, while these systems are valuable and have done much to maintain the financial position of organizations, they cannot, by their very nature, deal with the more dynamic aspects of an organization which are vital to its health.

To know that production is at a given level, that output per man-hour is in an acceptable range and that deliveries are on time, is not necessarily to know that the organization is healthy and is likely to continue in good health. Somehow there must come back through the stages of delegation word of the progress being made, of all those detailed decisions which build up the trend of policy, and, if uncontrolled, can change the direction of policy or stultify its purpose. Because of the nature of these things each delegate must make his own summaries for transmission back to his superior. The manager must realize that this system, being dependent on human judgment, is fallible. It will let him down by failing to give him, on some occasion, information he needs. It will load him quite frequently with information he does not need. If those to whom he has delegated his duties are well led and well chosen, the errors will not be gross ones and the manager will not find that the system is running him. If on the other hand the delegates are not well chosen, or if the instructions they receive are not precise, or if the underlying principles on which policy is based are not understood, then the delegates are likely to fail to send back to the manager vital pieces of information, or else to overwhelm him with detail.

The flow of data must therefore be two-way. The delegates must receive sufficient information to enable them to understand the manager's views and policies just as they must send to the manager the information which bears on the development and progress of these policies. It is probable that this two-way flow of information can best be organized in steps. These steps will naturally correspond to the successive steps in delegation so that the duty of transferring information, which is a derivative of delegation, is itself a subject of delegation. The methods to be adopted will vary with circumstances. Regular formal meetings have their place and form an excellent foundation for a two-way communication system. To be fully effective they should not bring together too many levels of delegation. It is probably ideal to have not more than two levels represented in a meeting if the interchange is to be really frank and it is probably best that they are two adjacent levels of delegation. No matter how well organized such a formal system may be, it will not be adequate to meet all require-

ments and it will show the usual rapid diminution in return with over-elaboration. To get full control it is necessary that those to whom duties are delegated should have ready access to those above them for reporting and discussion. This informal and personal approach is the only possible channel for urgent matters, and, if not abused, is a valuable adjunct to the formal mechanism of regular meetings.

The desirability of such an informal contact between one level of delegation and another has its own implications regarding the mode of expansion of the system. For contacts of this type to be fully effective the number of people involved must be kept within limits. Too large a number will make it difficult to maintain the ease of contact which is important and will tend to make the whole operation become stilted and formal. Such a situation is usually unstable and for one reason or another some individuals develop closer contacts than others and a system of 'favourites' tends to develop. This development is neither efficient nor acceptable to the majority and distorts the whole system.

We have discussed delegation from the manager downwards in the organization through various grades to the foreman or shop supervisor. This is only one aspect, though perhaps the most absorbing from the point of view of the manager. The manager himself is using delegated authority, for he manages his unit on behalf of some higher authority. This authority lays on the manager certain duties. The manager's powers are limited and defined by the higher authority. The manager must keep the higher authority informed of his actions, of his progress along the lines laid down, of his setbacks and failures. The fact that the higher authority may, for the manager, be a composite group such as a committee of management does not alter the essential relationship which must exist throughout the system. For the manager as for all others in the system of delegation, it is essential that the limits of action be as clearly defined as is practicable and that the basis of policy be clearly understood. If these two requirements are not met there will be confusion and the destruction of the confidence that must exist if the undertaking is to be led to success.

The Psychology of Communication

At an informal meeting of the Radio and Telecommunication Section on the 4th February 1957, Dr. E. C. Cherry, of Imperial College, gave a talk on investigations into the way in which the brain marshals the information received by the senses—a study which is of importance to engineers working in the field of telecommunication, for the ultimate terminations of any communication system are human beings.

PSYCHOLOGY and the mechanism of sensory perception are unusual subjects for most electrical engineers, although cybernetics has focused some attention on them; and it was with lively curiosity that 120 members assembled in the Lecture Theatre for an informal evening on *The Importance of Research in Hearing and Seeing to the future of Telecommunication Engineering*, which was launched with a stimulating talk by Dr. E. C. Cherry.

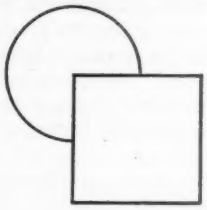
Dr. Cherry's thesis was that, although the telecommunication engineer has been traditionally concerned with designing equipment for the accurate transmission and reproduction of signals, his art has reached a state of near perfection, and research could now well afford to concern itself with the properties of the human speakers, listeners and viewers themselves. As the study of communication has grown, inspiration has been drawn from many other sciences, such as mathematics or semiconductors, and the latest science to be drawn into the bounds of telecommunication is practical psychology. Taking a wide view of the subject, Dr. Cherry said that a system does not communicate; *people* communicate with each other. Communication is the transmission of beliefs; the words of the speakers change the listener's state of belief, and the engineer's ultimate object might become, not so much to transmit signal waveforms faithfully, but rather to transmit those clues which are necessary to communicate the desired illusions, especially if this helps to reduce the present congestion of the ether. To do this requires an extensive study of the human mind. It is still a widely held belief that human beings are not describable by precise laws, that 'human variability', 'free will' or 'human nature' make us lie outside scientific method, as objects of study. It is further held, sometimes, that the subjective element enters into any such study and that this is, in some mystical way, scientifically indecent. But the whole field of experimental psychology has arisen because laws can be formulated which describe human behaviour, though these may not be strict causal laws, but statistical laws. Further, subjective effects are quite measurable objectively (i.e. repeatably and predictably) by statistical means. If first-class experimental psychologists worked together with communication engineers we might well be in a better position to design speech-compression systems.

We perceive, said Dr. Cherry, only a minute fraction of our environment, for the brain discriminates and selects from the mass of information available to our senses. In speech, 50 000 bits of information impinge on our ears every second, while, in reading, the flow of information amounts to millions of bits per second. Dr. Cherry then demonstrated a machine* which, he claimed,

* This machine was based upon a principle shown first by Dr. W. E. Hick in 1950.

was able to measure the rate at which the brain can cope with information. The machine consists of a row of lamps with a button switch beneath each of them. One of the lamps is alight, but, on pressing the switch below it, it goes out and another lamp, chosen automatically by the machine on the 'roulette-wheel' principle, springs alight. The object is to switch out the lights as fast as possible, and the rate at which this is done yields the speed with which the brain can cope with bits of information. It is clearly a very small fraction of the rate at which information is absorbed by our senses.

From this intake of information the brain forms *Gestalten*, or complete impressions, which may be more



significant than the individual constituent parts. This was illustrated with the diagram shown. The brain interprets the diagram as a square superimposed on a circle, although no circle exists.

In a similar manner the brain solves what Dr. Cherry called the 'cocktail party' problem; namely that of singling out one speaker from a room full of talking people. An example was given of two recorded commentaries made simultaneously. It was found that only one commentary could be followed at a time, although the attention could, of course, be switched from one to the other. The mechanism by which the brain does this is unknown. Why do not two simultaneous conversations appear like a new experience—a new language, say?

It is by means of *Gestalten* formation that distorted speech can be understood, for the mind fills in what is missing. Words are 'pigeon-holes' in a listener's mind. Learning is the construction of more pigeon-holes.

On the subject of binaural fusion, Dr. Cherry said that most of our knowledge is empirical; we do not understand how we can determine the direction of sound, for example, or why it is that sounds in real life appear to lie outside the head. He gave a demonstration of two simultaneous flute notes; the flutes appeared to be outside the head of the listener, but the beat notes inside.

Similar psychological problems arise with sight as with hearing. Although our total visual area is fairly large, the area of really clear vision subtends an angle of only one degree at the eye; when viewing, the eye fixes on each point for a quarter of a second. An object seen for less than that time may be recognized if it is familiar, but its peculiarities will pass unnoticed. Letters of the alphabet were flashed on the screen for a twentieth of a second, in which time they could just be recognized by the audience.

Dr. Cherry said, however, that investigations of individual human beings stress their variable modes of perception. If a human being is considered as a mysterious piece of apparatus enclosed in a container, we must not expect the internal structures and parameters to remain constant, as is usual with communication equipment, for they may change not only with the nature of the task but even during the performance of a task.

The ensuing discussion revealed great enthusiasm on the part of the audience, as well as perplexity and controversy. Mr. C. W. Earp maintained that the talk had been justified by the interest it had aroused, but he could not himself see any immediate use for this kind of study. He ended by saying that it might be useful to be able to stimulate artificially a taste such as that of good Scotch whisky. Dr. Cherry said in reply that he did not intend to go quite as far as the realization of Aldous Huxley's ideas about the 'feelies'.

Mr. J. Moir, who has worked on stereophonic film systems, made the point that experience plays a part in deciding the position of a source of sound. Dr. Cherry agreed that past experience was a vital matter and said that inferences depend on *a priori* probabilities; he made the rather striking statement that we do not judge direction solely by means of the interval between the arrival of sound at the two ears. Stereophonic systems are purely illusory, for the position of a sound source does not depend on the reproducing apparatus alone but on the nature of the sound.

Mr. Brittain was also rather puzzled about the application of the subjective phenomena under discussion. He amused the audience by showing on the screen first a photograph of a cat, and then a cartoon of a cat made by a few simple strokes of the pen. How, he asked, does the brain associate two such different pictures? Dr. Cherry replied that the cartoon problem was most interesting, and that an artist is the ideal band-compressor! He has the faculty of selecting those clues which are vital to the desired perceptions.

In Major W. V. Fuge's opinion, there was nothing remarkable about the phenomena they were discussing, and as far as the problem of crosstalk was concerned, it was the relative loudness that was the criterion. He maintained that the purpose of communication systems was certainly to convey information from one person to another, and that for this purpose it was essential to transmit the whole of a message, as was done at present.

Another member felt that the engineer might well gain help from the biologist, while several speakers thought that the effort which is spent on obtaining high quality might be misdirected; it was more important to educate people in the proper use of the communication facilities. That even to-day our sound reproduction systems fall short of perfection was brought out by one contributor, who said that, if a man brought up on music from a loudspeaker were to visit the Albert Hall, his reaction might well be, 'Oh, far too much bass!'

The Chairman, Dr. R. C. G. Williams, closed the meeting and in proposing a vote of thanks to the author commented that Dr. Cherry had put precept into practice in his talk; his enunciation was first-class.

620.92 ENERGY SUPPLIES DURING THE NEXT FIFTY YEARS

This article is based on the Chairman's Address to the East Anglian Sub-Centre given by Mr. Sumner at Norwich on the 8th October 1956. It discusses the widening gap between demand for and supply of fuel in Western Europe, including the United Kingdom, and points out that, although nuclear energy will eventually close this gap, it is unlikely to do so until early in the next century, even allowing for greatly intensified nuclear energy programmes, such as the one for the United Kingdom which was announced last month by Lord Mills. During the remainder of this century Western Europe may be hard put to find enough energy to support an expanding economy. The international events in the Middle East which have occurred since the address was delivered have painfully shown the danger of relying on oil to close the fuel gap. The author, who is with the Eastern Electricity Board, suggests that the widespread use of the heat pump for space heating would do much to alleviate the problem.

J. A. SUMNER, M.I.MECH.E., MEMBER

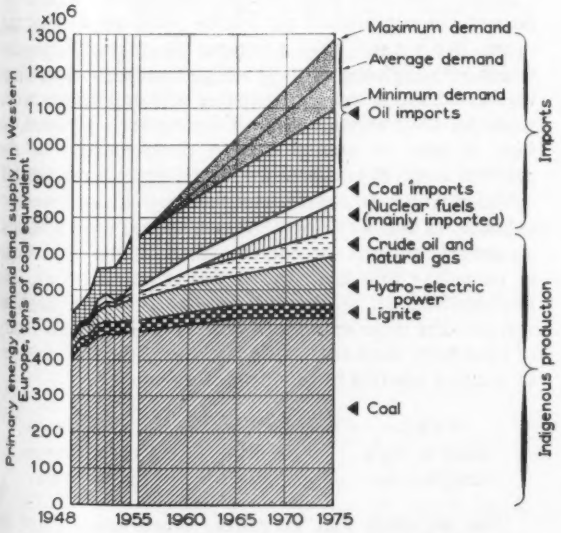
I AM proposing to discuss the heat pump and to show that there is a case for using it in the United Kingdom and Western Europe. One can imagine that Hero, in talking about his steam turbine to the local Engineering Society of Alexandria two thousand years ago, was told by his critics—with some justification—that it was of purely academic interest and not capable of practical use. The same criticism was made of Lord Kelvin one hundred years ago when he gave us his conception of, and specification for, a heat pump.

I am, therefore, going to try to show that our long-term fuel situation in the United Kingdom and Western Europe is more serious than many people think—quite apart from the immediate difficulties caused by Col. Nasser's seizure of the Suez Canal—and that the use of heat pumps is not academic but necessary. In a society where fuel production is greater than requirements, the saving of a ton of fuel is, admittedly, of largely academic interest, but in a society where the fuel requirements are greater than the fuel available (and this is the position in Great Britain to-day), we should surely give serious thought to devoting labour and materials to the manufacture of heat pumps if it can be shown that they would achieve a substantial saving. Lord Kelvin called his machine a 'fuel multiplier'—a term which I want to explain later.

The Dissipation of Nature's Fuel Stores

For many millions of years the sun, by the process of photosynthesis, has produced something of the order of 10^{11} tons of vegetation each year, and the same amount of oxygen. During the whole of this period the vegetation and animal life died and decayed and became stored up in the form of coal, oil or peat—a growing accumulation of fuel that remained largely untapped.

Then, only two centuries or so ago, the industrial age began—first in this country and then throughout the western world. British forests were first denuded, and the exploitation of our coal reserves followed. In Great Britain (and probably in the whole of Western Europe) the maximum output of coal has been passed, and a steadily decreasing annual coal output is inevitable in the future. In the western world as a whole we used about 1 million tons of oil in 1900; to-day this figure is nearly 1000 million tons per year. So, in Western Europe in general and in Great Britain in particular, we face a period of rapid growth in fuel requirements at a time when our output of indigenous fuel is decreasing. Western Europe has ceased to export energy since 1929. In a competitive world we are becoming more and more dependent upon imported oil and the long-term promise of nuclear energy. Remarkable achievements have been made by the Atomic Energy Commission and the Central Electricity Authority in developing atomic power stations, but the question is whether these can be built at a rate sufficient to close the gap between declining fossil-fuel output and the increasing demand for energy throughout the world. The graph shows the estimated position for Western Europe as a whole during the next twenty years—prepared by the experts of the



Estimated demand and supply of energy in Western Europe

Reproduced by courtesy of the O.E.E.C.

O.E.E.C.* Very roughly, the same curve applies to Great Britain if the vertical scale is reduced by two-thirds and the contributions due to lignite and hydro-electric power are deleted. All the indications are that nuclear energy may close the gap early in the twenty-first century, but that a critical position may arise during the interim period represented by the latter part of the twentieth century.

The Economic Value of Saving Fuel

The problem which I am bringing to your notice, therefore, is that of the possibility of a serious 'fuel gap' which could arise during the period between the decline of our native coal supplies and the rise of atomic power early in the next century.

The demand for oil in the United States towards the end of the century may prove to be greater than the whole world's output of oil, and there are reasons—some at least of which are all too apparent at the moment—for thinking that oil is likely to be a precarious source of fuel in the coming years so far as Great Britain, and even Western Europe, is concerned.

Capital expenditure which will save a ton of fuel annually is probably more valuable than the same amount of capital expenditure on the production or distribution of fuel, and it would appear that more attention should be given to this aspect of the question. The growing use of electricity in place of coal for domestic-heating purposes, etc., provides many advantages in the form of cleaner atmosphere, the preservation of buildings and the reduction of inter-urban transport. But it does not result in an appreciable saving of coal.

It has been estimated recently that Great Britain can afford to spend about £100 in capital equipment for each ton of fuel saved annually. Sixty-five million tons of coal are used each year in this country in domestic dwellings. If, by some miracle, we could save 40 million of those tons each year, we could expend £4000 million in providing fuel-saving apparatus.

What is the Chief Energy Requirement of the World?

Without any doubt at all, the most important energy requirement is that of meeting man's personal need, i.e. that of keeping his body warm, either by making food palatable so that he can produce heat internally, or by space heating. Thus, the energy requirement for space heating is, and always will be, the chief need, and it accounts for more than half the fuel consumption of the world.

Electricity and Heating Requirements†

I think there is a distinct possibility that, as coal becomes more scarce and expensive, people will turn from coal to electricity for their heating requirements. Coal now costs nearly 1d. per lb, and it may soon exceed that figure. Assuming the average efficiency of burning in the household is 30%, we get 3400 B.t.u. of heat per pennyworth of coal into our houses. If we burn 1 lb of coal in our power stations to make electricity, it will provide the same heat energy in an electric radiator *for the same price of 1d.* Thus, from the viewpoint of coal conservation, the country would not benefit by a change to electricity for space heating, even with coal at 1d. per lb and electricity at 1d. per kWh.

This obviously leads to the question: can the electricity industry take over this load and find a means of supplying the same domestic heating requirements by burning only one-half or one-quarter of the amount of coal? I think it can, and I shall suggest how this can be done. But before doing so let me summarize the position:

(*a*) The world demand on its stored-fuel supplies is becoming incredibly greater each year, and we do not know how much of this store is left.

(*b*) A significant contribution from nuclear energy lies in the future, and its rate of growth is unknown.

(*c*) Great Britain is in a singularly precarious condition because her supply of indigenous fuel is now much less than the demand.

(*d*) A change from coal to electricity supply for domestic heating in Great Britain would make no contribution whatever to her serious fuel problem, unless the industry can find a means of making one kilowatt-hour of electricity, when used for heating, do as much work as, say, three or four kilowatt-hours at present.

The Heat Pump

If we compress air, its temperature will rise, and heat at a higher temperature will become available. May I make it quite clear that the heat that one obtains during such compression is exactly equal to the amount of work which is done in compressing the air. So far, therefore, we have only obtained an amount of heat exactly equivalent to the amount of work done.

Now, if we wait long enough, the higher-temperature heat of the compressed air will be given up to heat the room. But we still have a volume of air in the cylinder which, although cooled, is at a higher pressure than when we started and is therefore capable of doing further work when we let it expand back to atmospheric pressure. In fact, it may be enough to do three-quarters of the original work of compression if we feed it into another cylinder which is coupled to the original compression cylinder. In this way, therefore, we should have obtained an amount of heat for only a quarter of the work done in providing that heat, or, to put it another way, one kilowatt-hour of electricity used to drive the machine will give the same amount of heat as four kilowatt-hours of electricity used for heating in the orthodox manner. One could put this in the form of an equation:

4 kWh	=	1 kWh	+	3 kWh
Heat at high temperature		Work		Heat at lower temperature

Now we know that we cannot create energy, and so where did this extra 3 kWh of heat come from? Obviously it is heat that was already present in the air at a lower

* 'Europe's Growing Needs of Energy. How can they be met?' (O.E.E.C., 1956).

† It should be noted that the article was written before the impending increases in the cost per kilowatt-hour of electricity were announced by certain Area Boards. Should the price of coal remain at its present level, some of the argument in this section would need modification to allow for the increased electricity tariffs.

temperature than the room, and it has been up-graded to the higher temperature sufficient to warm the room. The heat pump, in fact, draws heat from a low-temperature source and pumps it into a higher temperature sink.

The Effect of Heat Pumps on the Nation's Heating Budget

The heat energy of 65 million tons of coal at 30% efficiency is equivalent to 130 million MWh. This is nearly twice the present total annual output of all power stations.

This heating load, at 10% annual load factor, represents plant capacity of about 130 000 MW or about eight times the present available capacity in all stations. If heat pumps were used with a performance energy ratio* of 3·5 and an annual load factor of 30%, a reduction from 130 million MWh to 37 million MWh per annum would result, and the necessary plant capacity would be 11 000 MW instead of 130 000 MW. The coal consumption at the power stations would be 18·5 million tons per year instead of 65 million tons—an annual saving of 47 million tons of coal.

* The performance energy ratio is defined as the ratio of the heat output at the higher temperature to the heat equivalent of the work input. It takes account of all local inefficiencies.

We could, therefore, as a nation, spend 100 × £47 million, i.e. £4 700 million, in capital equipment on heat pumps in place of expenditure on machinery and facilities to bolster up a declining fossil-fuel supply.

May I suggest that I have shown a way in which the electricity supply industry could make a substantial contribution to the serious fuel problem that is likely to face Great Britain during the remainder of this century.

Conclusion

A scheme of such magnitude would require the wholehearted support of the industry. There would be a need on the part of all the Boards and of the Central Electricity Authority to overcome prejudice and to examine the potentialities of the heat pump. No one person can do this alone, and at least one Board must put its resources behind the inquiry. To foster public interest the concentration of the Boards' immense selling organization should be behind this scheme, with or without the co-operation of manufacturers.

Nature has given us illimitable sources of prepared low-grade heat. Will human organizations co-operate to provide the machine to use Nature's gift?

CORRESPONDENCE

TRANSACTIVE NETWORK ELEMENTS

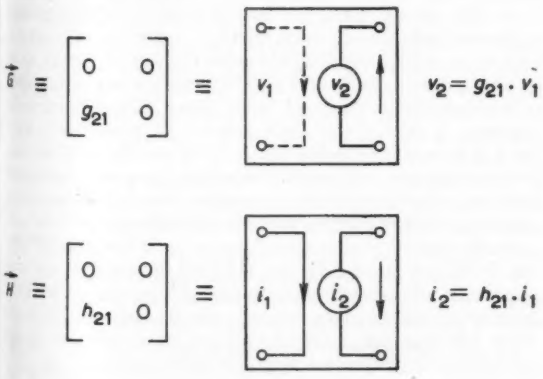
From A. W. KEEN, ASSOCIATE MEMBER

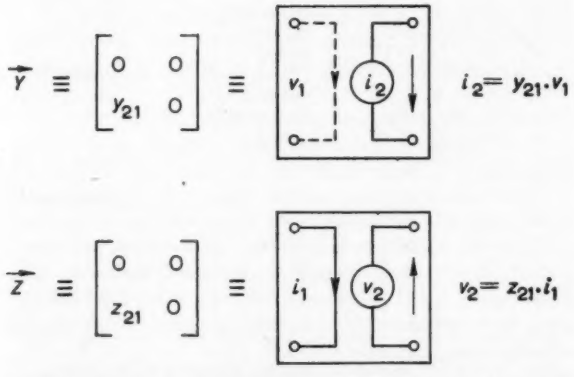
Having used transactors, both in concept[1, 2] and in name, for a number of years, chiefly for the purpose of constructing theoretical models of electronic devices,[3] I was interested to read Mr. G. E. Sharpe's letter in the January issue of the *Journal*.

The name 'transactor' is used to describe two-terminal-pair networks characterized by *G*, *H*, *Y* or *Z* matrices having a null principal diagonal, particularly those having one zero also in their secondary diagonal. Eight cases are distinguished, as defined in terms of admittance matrix elements in the table; each has four forms, namely *G*, *H*, *Y* and *Z*, which are shown in matrix and equivalent-circuit form for the forward-acting unilateral case in Fig. 1. It will be seen that the gyrator and the unilateral $v \rightarrow i$ and $i \rightarrow v$ forms mentioned in Mr. Sharpe's letter are only a few of a more extensive set of idealized elements.

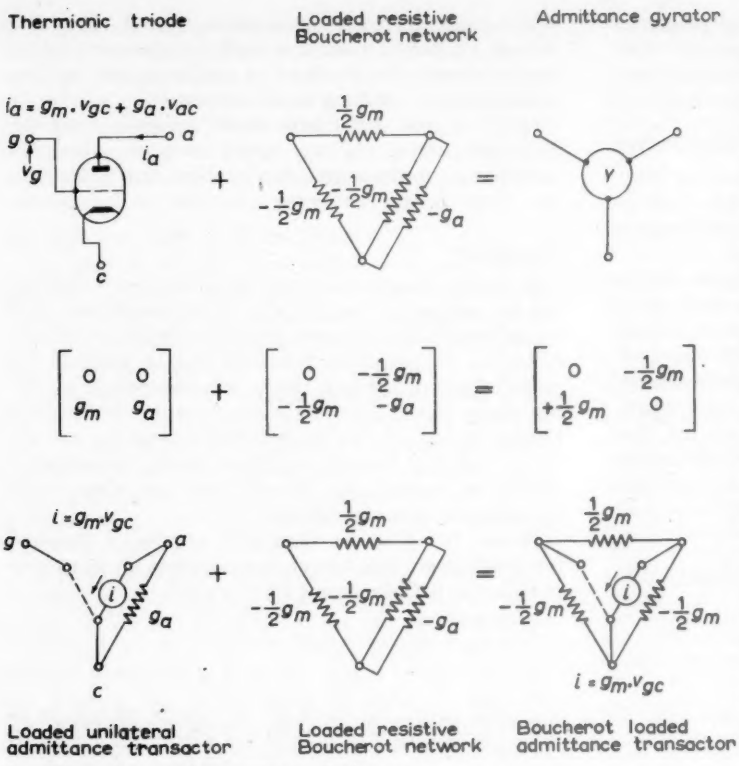
It is interesting to construct networks of these elements. For this purpose it is generally necessary to interpose passive transmission networks because of disparities between the impedance properties of the transactors; thus, a current-input transactor cannot directly follow one having voltage output.

Mr. Keen is a Senior Lecturer in the Electrical Engineering Department, Coventry Technical College.


$\vec{G} \equiv \begin{bmatrix} 0 & 0 \\ g_{21} & 0 \end{bmatrix} \equiv$
v_1
v_2
$v_2 = g_{21} \cdot v_1$
$\vec{H} \equiv \begin{bmatrix} 0 & 0 \\ h_{21} & 0 \end{bmatrix} \equiv$
i_1
i_2
$i_2 = h_{21} \cdot i_1$


$\vec{Y} \equiv \begin{bmatrix} 0 & 0 \\ y_{21} & 0 \end{bmatrix} \equiv$
v_1
i_2
$i_2 = y_{21} \cdot v_1$
$\vec{Z} \equiv \begin{bmatrix} 0 & 0 \\ z_{21} & 0 \end{bmatrix} \equiv$
i_1
v_2
$v_2 = z_{21} \cdot i_1$

1 *The unilateral forward-acting transactor in G, H, Y and Z forms*



2 *Illustrative set of transactor equivalences*

Such networks are generalized forms of electronic circuits, with the transactors replacing thermionic or transistor elements. Conversely, the various types of transactive element may be realized physically in the form of appropriate electronic circuits. For example, the unilateral types may be simulated by applying heavy feedback over a high-gain unilateral voltage amplifier, through a unilateral (e.g. cathode follower) feedback path. The *G*, *H*, *Y*, *Z* forms require respectively series-shunt, shunt-series, series-series, and shunt-shunt connection of the terminals of the various sections of the feedback loop. For analytical purposes the unilateral admittance transactor is to be preferred in so far as it is the most readily realizable form, being very accurately simulated by a high-mu pentode valve having a non-bypassed cathode-lead resistor. The unilateral voltage transactor, too, can be closely approximated—by a single-valve (cathode-follower) circuit. A set of equivalences, chosen to illustrate the foregoing, is given in Fig. 2; it includes both symmetrical and asymmetrical forms of bilateral transactor, together with a unilateral type and its physical near-equivalent (the triode).

One concludes that the unilateral forms of transactor are preferable to the asymmetrical bilateral (gyrator) forms for the following reasons:

(i) They are realizable as relatively simple thermionic amplifier circuits.

(ii) Their physical action is easier to visualize, because the action of their thermionic counterparts is so familiar.

(iii) They are more fundamental, in so far as a gyrator may be resolved into a pair of unilateral transactors of equal magnitude and opposite sign.

Classification of transactive elements

Matrix Element Valves				Description	
y_{11}	y_{12}	y_{21}	y_{22}	Directivity	Symmetry
0	0	+	0	Unilateral forward-acting	Asymmetrical*
0	0	−	0		
0	+	0	0	Unilateral backward acting	
0	−	0	0		
0	+	+	0	Bilateral	Symmetrical†
0	−	−	0		
0	+	−	0		Skew-symmetrical‡
0	−	+	0		

* The basic transactors.
† May be described as resistive Boucherot networks (see BARTLETT, A. C.: 'Boucherot's Constant-Current Networks and their Relation to Electric Wave Filters', *Journal I.E.E.*, 65, 1927, p. 373).
‡ Generally called *gyrators* (see TELLEGEN, B. D. H.: 'The Gyrator, a New Electric Network Element', *Philips Research Reports*, 3, 1948, p. 81).

1 KEEN, A. W.: 'Automatic Stabilization of Amplifier Gain', *Journal of the British Institution of Radio Engineers*, 10, 1950, p. 198. (See Fig. 1*a*.)
2 KEEN, A. W.: 'Positive Feedback Operator Networks', *ibid.*, 12, 1952, p. 395. (See Fig. 3.)
3 KEEN, A. W.: 'Triode Transmission Networks', *Wireless Engineer*, 28, 1951, p. 56.

ARS MARTIS COMES

From F. E. WALLCROFT, ASSOCIATE

I was very intrigued to see the above motto on the contents page of the February issue of the *Journal* and hurriedly turned to p. 108 to see what had brought the London Electrical Engineers into prominence. The article was of considerable interest to anyone who has served in the L.E.E., but those of us who did so between 1914 and 1918 cannot but be surprised to see our efforts dismissed in two lines. When I joined the regiment in 1916, I was too young to be interested in what the L.E.E. had been doing before 1914, but I should say that it had in the first two years of war taken on a completely new task involving considerable expansion; the task of providing searchlight crews for our anti-aircraft defences over a considerable area of the country. There is no doubt that by 1939 this work had assumed a very different complexion and that our earlier efforts were made to look old-fashioned, but I am sure there must be many still with us who, between 1914 and 1918, felt that they were playing an important part in the defences of the country and in the history of the I.E.E.

SHORT REVIEWS OF PAPERS

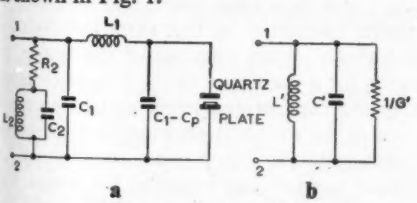
On the following pages are some brief review articles based on, and written by the authors of, current Institution papers. The authors have been asked to make these articles, so far as possible, interesting and of appeal to electrical engineers who have no specialized knowledge of the subjects, and the content of the articles is not necessarily confined to the subject-matter of the original papers.

F.M. Quartz Oscillators

A short review of a Radio and Telecommunication Section paper (No. 2302) entitled 'Frequency-Modulated Quartz Oscillators for Broadcasting Equipment', by W. S. Mortley, Associate Member. The paper was published individually in December 1956, and it will be republished in Part B of the Proceedings.

THE SIMPLEST FREQUENCY-MODULATED SYSTEM IS THE so-called *direct f.m.*, i.e. reactance-valve modulation, of an *LC* oscillator. Unfortunately such systems have inadequate frequency-stability, and although the centre frequency can be corrected by a servo-system relative to a crystal oscillator the complication of so doing is quite considerable, and short-time instabilities such as those due to microphonic effects are not reduced thereby.

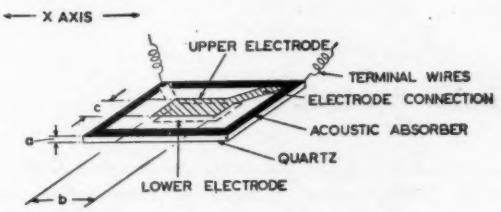
To produce an oscillator of adequate stability, a parallel resonator is required which has a low temperature-coefficient of frequency, a low value of L/C, a high Q-factor and great mechanical rigidity. Such a resonator is provided by a quartz-crystal plate in conjunction with a quarter-wave impedance-inverting network. The shunt capacitance of the crystal is eliminated by including it as part of the transforming network, leaving the series-resonant circuit (which is the electrical equivalent of the mechanical resonance) to be transformed into an effective parallel-resonant circuit with the required characteristics, as shown in Fig. 1.



1 *Quartz-crystal plate and coupling circuit*
a Practical circuit.
b Equivalent circuit near crystal resonance frequency.

This resonator is maintained in oscillation by a parallel negative conductance and modulated in frequency by a parallel modulated susceptance, i.e. by a so-called *reactance valve* circuit.

Most quartz-crystal resonators exhibit a number of unwanted resonances in addition to the main one, and in an equipment for broadcasting these might be excited by f.m. sidebands and cause distortion. For this reason a special resonator (Fig. 2) was designed on waveguide



2 *Quartz-crystal plate for frequency modulation*

principles, to put such resonances outside the band of the equipment and also to damp them by an absorber.

In a typical transmitter—the B.B.C. Third Programme transmitter at Wrotham—the resonator constants are as follows:

Resonance frequency $f_x = 3{\cdot}8083$ Mc/s
Effective inductance $L' = 0{\cdot}059\,\mu$H
Effective capacitance $C' = 0{\cdot}03\,\mu$F
Shunt conductance $G' = 3{\cdot}25 \times 10^{-5}$ mho
Q-factor $Q = 22\,000$
Temp. coefficient $f_x^{-1}df/dt < \pm 10^{-6}$ per °C

Frequency instabilities of the coupling circuit, such as those due to temperature and to microphonic effects, are reduced by a factor of 1200. Amplitude modulation is negligible.

In order to modulate the frequency of a resonator with such a large value of capacitance, it is necessary to use a modulator (balanced for stability) which is followed by an amplifier. The paper discusses modulator design as well as oscillator-circuit and crystal-plate design, and it describes methods for easy alignment which derive from the use of a resonator of high Q-factor. Performance figures are given for the Wrotham Third Programme transmitter. Similar results have been obtained with more than fifty drive units made subsequently, and the reliability and ease of maintenance of the system have been confirmed. Alignment is very simple indeed, and the main adjustments—modulator phase and linearity—

are made in the same manner as is used when balancing an impedance bridge.

There are applications for f.m. quartz oscillators in fields other than broadcasting. In some of these, much simpler arrangements can be used.

For frequency-shift keying, much smaller shifts and lower modulation frequencies are needed, and this simplifies both the modulator and the quartz plate. The use of the quartz oscillator results in considerable simplification of the equipment, and, since it is a true f.m. system, there is no difficulty in smoothing out keying transients.

An even simpler application is that of a tunable continuous-wave oscillator, the tuning of which is done by a variable condenser. With other restrictions removed, it is possible to vary the frequency by more than 1%, with a nearly linear relation between frequency and capacitance. 621.373.421 : 621.376.3

Magnetic Recording

A short review of a Radio and Telecommunication Section paper (No. 2296) entitled 'A Survey of Factors Limiting the Performance of Magnetic Recording Systems', by E. D. Daniel, M.A., Associate Member, P. E. Axon, O.B.E., M.Sc., Ph.D., Associate Member, and W. T. Frost, Graduate. The paper was published in March in Part B of the Proceedings.

THE INHERENT CONVENIENCE OF MAGNETIC RECORDING has led to its use in a variety of applications and to a demand for its use in a wider field. In practice the information to be stored is transformed into electric signals which are fed to a magnetic recording head. This head effects equivalent changes in the magnetization along the length of a moving magnetic tape or around a rotating magnetic drum or disc. When the sound is being reproduced, the magnetized medium is driven, usually at the same speed, past a reproducing head, and the lines of magnetic flux from the moving medium induce e.m.f.'s in the head depending on the original signals which created the magnetization. Development has not reached the stage when the method may be fully exploited, and the paper surveys the various factors which limit the performance of magnetic recording and restrict its application.

The overall frequency response is determined by factors in both the recording and reproducing processes; some of these factors are fundamental to the method, some arise from the properties of the materials composing the heads and recording medium and others from limitations of manufacture and constructional accuracy. Some factors which limit the frequency response are, in fact, wavelength phenomena—the wavelength in the recording medium being the quotient of recording speed and recording-signal frequency. The main losses of this type arise when dealing with either very short or very long wavelengths. Lack of resolution in the short-wavelength region may be due to unsuitable gaps in the heads, to misalignment between the recording- and reproducing-head gaps, or to separation of the recording medium from the surface of the heads. Where the latter is intentional, as in rotating-drum systems, it is usually the overriding factor, but even in tape systems, where the heads are nominally in contact with the medium, there will be some effective value of separation which may vary and create severe amplitude modulation of the signal. Where the recording speed is such that short wavelengths are associated with high frequencies, the response is further limited by magnetic losses, rising with frequency, in the cores of the heads.

At long wavelengths the fundamental response of the reproducing head falls with increasing wavelength at 6 dB per octave. A further decrease occurs as the overall length of the head in the direction of travel of the recording medium becomes comparable with the wavelength, so that the head becomes less efficient in collecting the flux.

When we consider only wavelength effects, it is obvious that the wavelength corresponding to a particular frequency may be altered by a change of recording speed, but in this respect the requirements for the effective recording and reproduction of very high and very low frequencies are usually opposing requirements. For example, increase of tape speed to overcome a lack of resolution in the system, and hence improve its high-frequency response, will only aggravate the difficulties in the low-frequency region, where the wavelengths will be further increased. One solution to low-frequency and long-wavelength difficulties is the adoption of a carrier-frequency system in which the signals to be stored are made to modulate a higher frequency carrier. The modulated carrier is then recorded, and on reproduction it is demodulated in the normal way to recover the original intelligence. If frequency modulation of the carrier is adopted the effects of unwanted amplitude modulation of the signal are mitigated. When the modulating signal contains high frequencies, it is necessary to use a high carrier frequency, so that extra demands are made on the high-frequency response of the system. In general this calls for a reduction of the frequency losses which occur in the conventional core, and (if excessive tape speeds are to be avoided) an improvement in the short-wavelength response. The primary requirement for high resolution is a short gap length in the heads. For example, to reproduce 3 Mc/s, recorded at 200 inches/sec tape speed, requires a gap length of 0·035 mil, and the gap must be straight and parallel-sided over the whole width of the track. Such a very small front gap reduces the head sensitivity, however, and this must be restored, as far as possible, by increased attention to the design of the core shape and suitable choice of core material. Laminated magnetic-alloy cores are in common use, but for high frequencies (say 100 kc/s upwards) it is often

desirable to use ferrite cores. The mechanical properties of the latter do not, at present, allow the production of a durable accurate gap, and it may thus be necessary to locate the gap in a thin lamination of magnetic alloy covering the face of the head.

Even when, by this or other means, a suitable head is produced, the performance of the system may fall short of the standard required owing to inadequacies in the tape and the tape-transport mechanism. The short-wavelength response may vary violently—for example when small movements of the tape alter the alignment required between the recorded track and the reproducing gap. Elimination of such variations demands extremely accurate guiding of the tape and an extremely fine tolerance in the tape guides adjacent to the heads. This is possible only when an equally fine tolerance in the width of the tape is maintained in manufacture—which is not always achieved.

Amplitude changes in the final output may also result from a variation in the effective separation of the tape from the heads, and a random component of this nature is introduced when the surface of the coating, which consists of fine crystals, is not sufficiently smooth or uniform. Physical shortcomings of this sort, as well as those which may exist in the driving mechanism itself, cause variations in the speed of the tape over the heads and this limits the ability of the system to store signals requiring high precision in time. An interesting phenomenon of this sort is the occurrence of comparatively high-frequency mechanical oscillations—excited by friction—in the tape passing over the heads.

For many of the applications in which the magnetic-recording system is at present employed, and for many in which its use may be envisaged in the future, an improvement in the high-frequency and short-wavelength performance appears to be a pressing requirement. The best avenues towards this are an increasing refinement in the manufacture of both heads and tapes and the development, if possible, of improved materials suitable for use in high-frequency-head cores. 621.395.625.3

Oscillograph Performance Limits

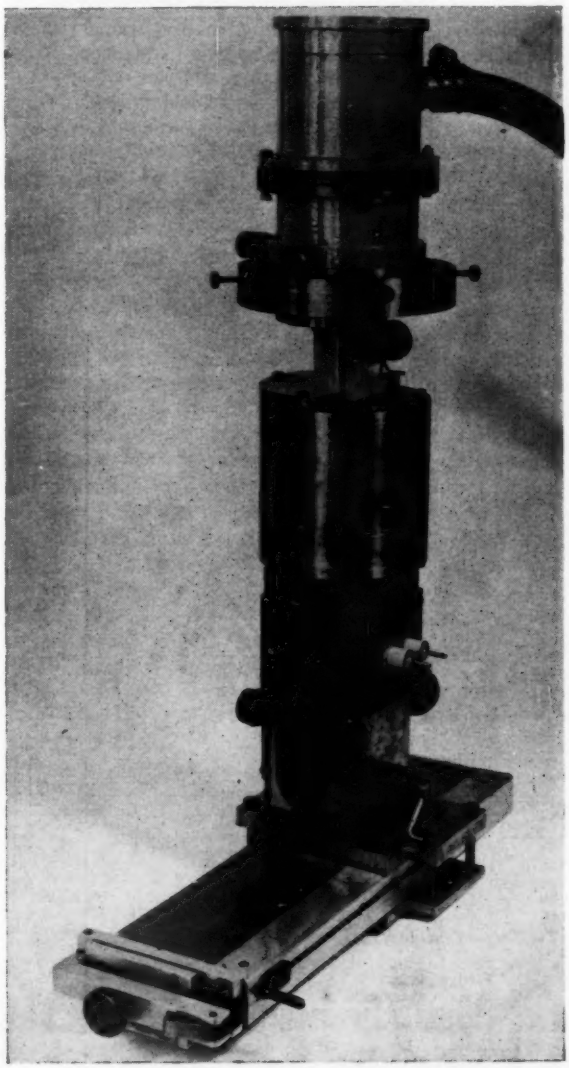
A short review of two Measurement and Control Section papers (Nos. 2306 and 2307) entitled 'The Ultimate Performance of the Single-Trace High-Speed Oscillograph', and 'The Design and Performance of a New Experimental Single-Transient Oscillograph with Very High Writing Speed', by M. E. Haine, M.Sc., F.Inst.P., Member, and M. W. Jervis, M.Sc.Tech., Associate Member. The papers were published individually in January and February 1957, and they will be republished in Part B of the Proceedings.

BEFORE 1940, CONTINUOUSLY EVACUATED CATHODE-RAY oscillographs were normally used for recording single high-speed electrical transients. Subsequently, sealed-off tubes were shown to be capable of a performance sufficient for most purposes, and these have largely displaced the continuously evacuated instruments, but little effort appears to have been made to analyse either the relative theoretical performance of the two methods or the limits of performance of either. In their first paper the authors investigate this question and in their second they describe an experiment designed to verify the conclusions drawn from their analysis.

The writing speed or *temporal resolution* τ is defined as the minimum time taken for the spot to move one diameter and still be recordable, and it is given by the equation

$$\tau = \frac{\sigma}{J}$$

1 *General view of the oscillograph*
The overall height is 24 inches.



where σ is the electrical charge density required to make satisfactory blackening of the recording medium, and J is the current density in the writing spot. With the continuously evacuated oscillograph the recording is usually, though not necessarily, made by the direct action of electrons on a photographic plate, while in the sealed-off instrument, the oscillogram is obtained by the external photography of the light emitted when the electron beam strikes a fluorescent screen.

The sensitivity of recording σ for the direct method has been measured, and, for an electron energy of 30 keV, it is about 4×10^{-12} coulomb/cm^2 for a trace of density 0·2. The sensitivity for external photography is calculated in the paper, and it is shown to be at least as good as that of the direct method.

The analysis shows that for a given maximum cathode-current density, cathode temperature and electron energy, the limiting temporal resolution can be related to the geometry of the electron focusing lens and optical system. The effect of space-charge spreading in the converging beam introduces a further limitation, which requires a minimum focused spot size. This cannot be less than the resolving power of the fluorescent screen or photographic plate, so that this size of spot is the optimum, and gives an optimum size for the oscillograph. The length of the deflector plates is related to the oscillograph size, and their minimum spacing depends on the beam diameter in the region of the plates. From these relations an expression is obtained giving the recording speed as a function of the deflection sensitivity.

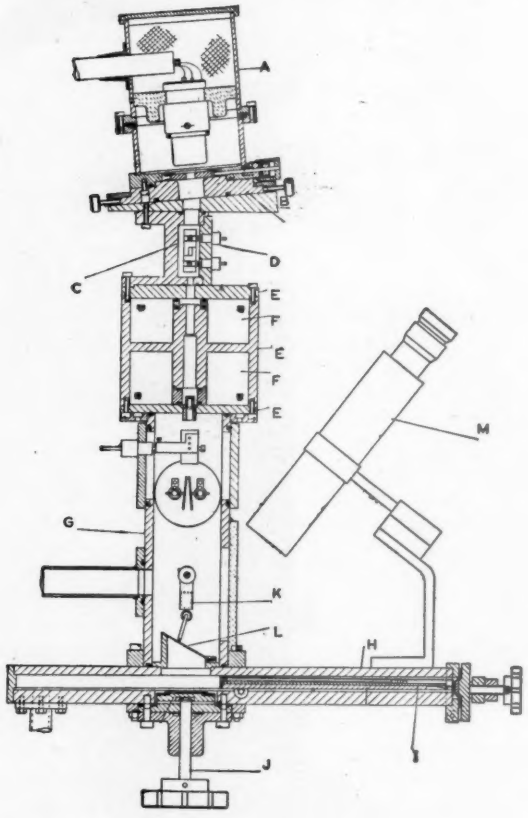
The table shows how the temporal resolution in an oscillograph of optimum design varies with the electron accelerating voltage V_0, deflection sensitivity n_a, and projection length v from the lens to the focused spot.

Limiting Values of τ

V_0	n_a	τ	α_n	I_b	J	v
kV	spot-width/volt	sec $\times 10^{-14}$	rad $\times 10^{-3}$	μA	amp/cm^2	cm
10	0·1	8·2	31	461	147	1·4
10	1·0	26	17	145	46	7·8
10	10·0	82	10	46	14·7	44
30	0·1	1·6	24	780	250	3·1
30	1·0	5	13	250	80	18
30	10·0	16	8	78	25	102
50	0·1	0·75	21	1 000	320	4·6
50	1·0	2·36	18	320	102	26
50	10·0	7·5	7	100	32	153

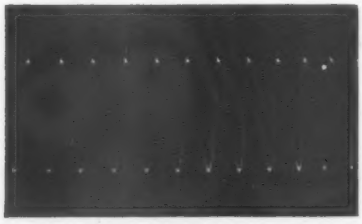
To verify some of the conclusions drawn from the analysis, an oscillograph, shown in Figs. 1 and 2, was constructed and tested. The instrument, which is about 24 inches high, is of the continuously evacuated type with direct recording, since this facilitates the measurement of the various quantities used in the analysis. It can be operated at voltages up to 50 kV and is fitted with a hot tungsten hairpin cathode in a biased electron gun. Two lenses are provided, giving a spot of diameter 20–30μ on the photographic plate, which is removable from the instrument through an air-lock.

The limiting writing speed was measured from single-stroke oscillograms of 9 080 Mc/s sine waves against a linear time-base. Conventional deflection plates are



2 *Section through oscillograph*

A. Electron gun.
B. Wedge plate.
C. Beam-trap chamber.
D. Insulators for beam-trap plates.
E. Lenses.
F. Coils.
G. Deflection chamber.
H. Camera box.
I. Cassette.
J. Actuating screw.
K. Faraday cage.
L. Fluorescent screen.
M. Telescope.



3 *Typical oscillogram*

Frequency of the timing wave = 9 080 Mc/s.
Temporal resolution = 5×10^{-13} sec/spot-width.

unsuitable for such frequencies, the transit time of the electrons through the deflection system being comparable with the sine-wave period. A parallel-wire system having a short transit time was therefore adopted, coupled to the 3 cm waveguide system from a magnetron.

The shortest time-base duration used was 2 millimicrosec, which was convenient for displaying a 9080 Mc/s waveform. The X-deflection system is conventional, the time-base waveform being obtained by discharging the capacitance of the system by means of the 20 amp anode current of a tetrode valve pulsed hard into grid current.

Oscillograms, such as that shown in Fig. 3, taken at 30 kV, indicate a limiting temporal resolution of 2×10^{-13} sec, which is in good agreement with the theoretical performance of the instrument. 621.317 75

Gaseous Insulants

A short review of a Measurement and Control Section paper (No. 2128) entitled 'Insulation Properties of Compressed Electronegative Gases', by P. R. Howard, Ph.D., B.Sc.(Eng.), Associate Member. The paper was published individually in August 1956, and it is republished this month in Part A of the Proceedings.

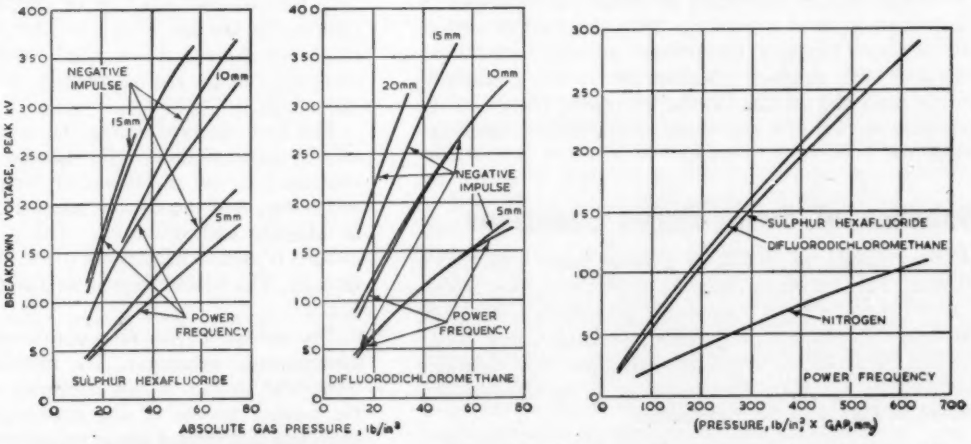
THE POTENTIALITIES OF COMPRESSED GASES FOR THE insulation of electrical apparatus have been appreciated for some time, and there are a number of practical applications, mainly using air, nitrogen and carbon dioxide. The electric strengths of these gases, however, are only comparable with those of liquids and solids when they are subjected to considerable compression. There has therefore been considerable interest in recent years in the electrical properties of complex halogenated molecular compounds which, in some cases, possess high dielectric strengths at relatively low pressures. The table gives the relative dielectric strengths at atmospheric pressure, in a uniform field and with nitrogen as the datum, for sulphur hexafluoride and some halogenated methane compounds.

From the data on breakdown strengths as functions of gas pressure and electrode geometry (sphere-sphere, point-sphere and coaxial cylinders), on the flashover-voltage characteristics of gaseous/solid interfaces, and on chemical and physical properties, it is concluded that two gases—sulphur hexafluoride (SF_6) and difluorodichloromethane (CF_2Cl_2)—seem to be worth considering for high-voltage insulation. Fig. 1 shows the breakdown characteristics of these gases under uniform field conditions, and Figs. 2 and 3 show the characteristics with a highly divergent field.

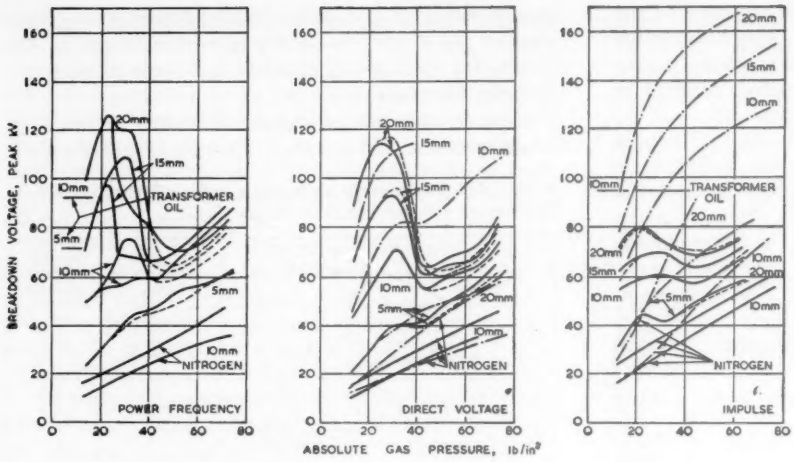
Relative dielectric strength of gases in a uniform field at atmospheric pressure and with nitrogen as the datum

Gaseous compound	Boiling point at atmospheric pressure, °C	Relative dielectric strength
Sulphur hexafluoride SF_6	− 62·0	2·6
Carbon tetrafluoride CF_4	−128·0	1·1
Trifluorochloromethane CF_3Cl	− 81·5	1·5
Difluorodichloromethane CF_2Cl_2	− 29·8	2·7
Monofluorotrichloromethane $CFCl_3$	23·7	3·9
Trifluoromethane CHF_3	− 84·0	0·9
Difluoromonochloromethane CHF_2Cl	− 40·8	1·2
Monofluorodichloromethane $CHFCl_2$	8·9	1·9

For general outdoor use, only sulphur hexafluoride in the undiluted state has a suitable vapour-pressure/temperature characteristic, but both, in undiluted form, are suitable for indoor applications. The dilution of the gases with nitrogen, which does not seriously affect the electric strength of either in uniform or non-uniform fields, has the advantages of saving in cost, lowering of the saturation temperature for a given total gas pressure, and reducing the severity of the effects arising from the dissociation of gas molecules when subjected to corona or flashover. For a total gas pressure of 60 lb/inch²,

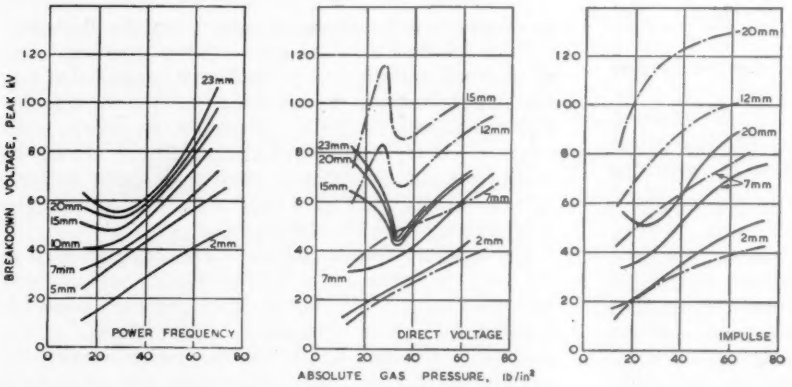


1 *Breakdown voltage between 5 cm-diameter spheres for sulphur hexafluoride and difluorodichloromethane as functions of gas pressure and of [pressure (lb/in²) × gap (mm)]*



2 *Breakdown voltage for sulphur hexafluoride with point-sphere electrodes*

——— Power frequency, positive d.c. and impulse.
– – – – Negative d.c. and impulse.
- - - - - Positive d.c. and impulse with radium.



3 *Breakdown voltage with difluorodichloromethane and non-irradiated point-sphere electrodes*

——— Power frequency, positive d.c. and impulse.
– – – – Negative d.c. and impulse.

dilution of difluorodichloromethane with nitrogen to give a partial electronegative gas pressure of 15 lb/inch² lowers the saturation temperature from 9° C to −29° C; the lowering of the electric strength in a uniform field is approximately 20%.

On the basis of providing the same power-frequency electric strength in a uniform field, the relative cost of the insulants nitrogen, transformer oil, difluorodichloromethane and sulphur hexafluoride in this country is in the ratio of 1 : 6 : 7 : 94; the interesting feature is the comparable cost of transformer oil and difluorodichloromethane. 621.618.9

Solution of Swing-Curve Equations

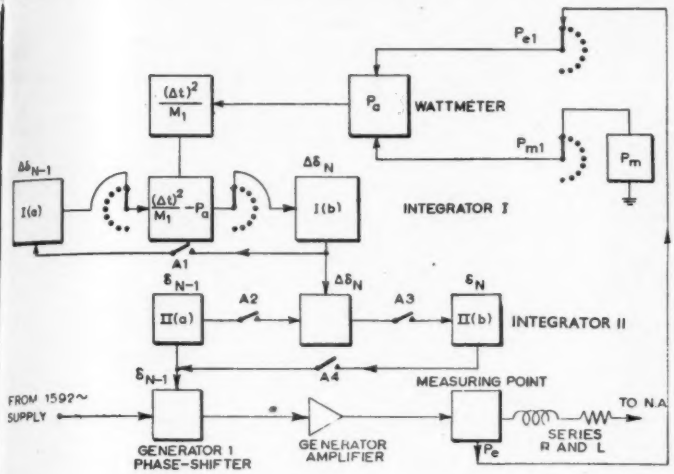
A short review of a Supply Section paper (No. 2035) entitled 'The Automatic Solution of Power-System Swing-Curve Equations', by C. Adamson, M.Sc.(Eng.), Associate Member, L. Barnes, M.Sc.Tech., Graduate, and B. D. Nellist, M.Sc.Tech., Graduate. The paper was published individually in May 1956, and it is republished this month in Part A of the Proceedings.

THE USUAL METHOD OF CALCULATING POWER-SYSTEM swing curves is by carrying out a double integration of the accelerating power by a step-by-step method. The values of the accelerating power can be obtained from a network analyser when one is available, the method then being applicable to systems containing a large number of generators. The resulting calculations are very tedious, and have to be checked at every step to reduce the chance of error. The paper describes two machines which, when used with an a.c. network analyser, make the derivation of the swing curves automatic.

The first machine solves the equations by the usual step-by-step method, the accelerating power being measured by an automatic null-reading dynamometer wattmeter, and the double integration being carried out in Magslip adding circuits. The output of the adding circuits is used to modify the phase angle of the generator directly. The block diagram of the machine is shown in Fig. 1.

The second device is a continuous analogue of the synchronous generator. Its method of operation is illustrated in Fig. 2. An electronic wattmeter measures the output power of the network-analyser generator, subtracts this from a signal proportional to the mechanical input power, and applies the resulting error signal to a d.c. amplifier and servo motor. The motor drives the

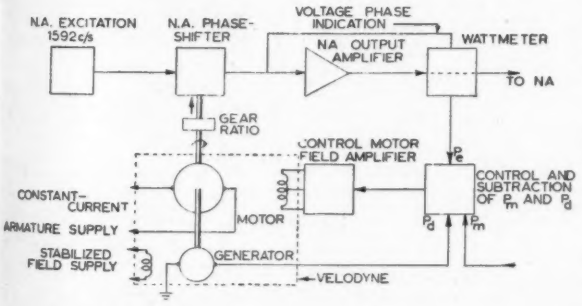
generator phase shifter in such a direction as to reduce the error by alteration of the output power. The complete circuit forms a second-order servo system, whose equation is of the same form as that of the synchronous



1 *Schematic of computer*

P_{e1} Electrical output power of generator 1.
P_{m1} Mechanical input power of generator 1.
P_a Accelerating power ($P_{e1}-P_{m1}$).
M_1 Inertia constant of generator 1.
Δt Duration of interval of integration.
δ_{N-1} Incremental angle added during (N–1)th interval.
A1 . . . A4 Control relay contacts.
N.A. Network Analyser.

machine. The servo equation can be made to simulate a given generator equation by adjustment of the values of the coefficients. The coefficients can be so chosen that the swing curves are obtained in real time, or on an extended time scale. With a large amount of damping,



2 *Schematic of simulator*

P_e Generator electrical output power.
P_m Generator mechanical input power.
P_d Damping power.
N.A. Network Analyser

this simulator can be used to set up the initial phase angle of the generator in steady-state studies, thus saving time.

621.315.09 : 621.3.016.35

Strength of Transformers

A short review of a Supply Section paper (No. 2317) entitled 'Mechanical Strength of Power Transformers in Service', by E. T. Norris, Member. The paper was published individually in February 1957, and it will be republished in Part A of the Proceedings.

IN THE SIXTY YEARS OR SO OF ELECTRICITY supply, transformers have grown steadily in size and they now weigh up to 200 tons or more. Any machine of this weight naturally presents certain structural and mechanical problems. However, since a transformer is static, has no moving parts and makes little noise, mechanical stresses are not at all obvious.

In transformers there are repulsive forces between primary and secondary windings, where the currents are in opposite directions, and attractive forces between parts of the same winding, where the current is in the same direction. These forces increase with the size of the transformer, but they are negligible under normal loading conditions even for large modern transformers.

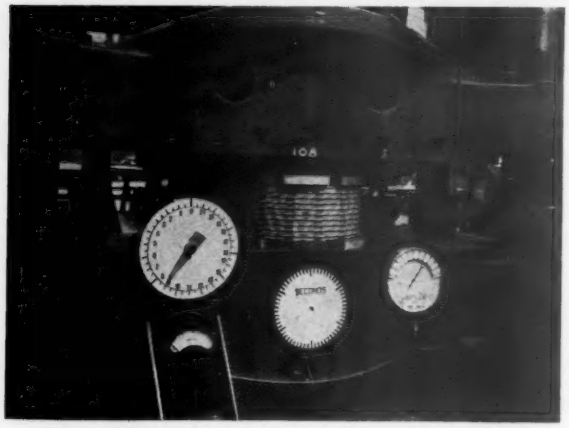
Unfortunately, transformers are subject to short-circuits, usually arising from earth faults, which are occasioned by flashovers from lightning or switching surges, by fog conditions and cable faults, etc. The short-circuit current is many times greater than normal and may initially be nearly doubled by asymmetry. The resulting forces are proportional to the square of the peak value of this current and may easily be many hundreds of times the normal value. It is these forces which constitute the problem in transformer design. Fortunately, short-circuits are rare, and under normal operating conditions occur between once a year and once in ten years.

The calculation of forces within windings has been dealt with extensively in the technical literature, but little attention has been given to the mechanical performance of transformers in service. This is perhaps because the performance has been apparently good and reassuring; it is not often that failures can be attributed specifically to mechanical stresses. The damage is such that it is seldom possible to decide whether failure was due initially to short-circuit stresses or to other causes such as over-heating or insulation breakdown. Moreover, most transformer specifications (national and otherwise) require that a transformer shall be short-circuit-proof. The acceptance of this requirement by manufacturers has generally given the impression that it is a technical and engineering achievement, whereas it has more likely been treated as an acceptable commercial risk.

There is, however, a general awareness in recent years that mechanical strength is already a serious matter and

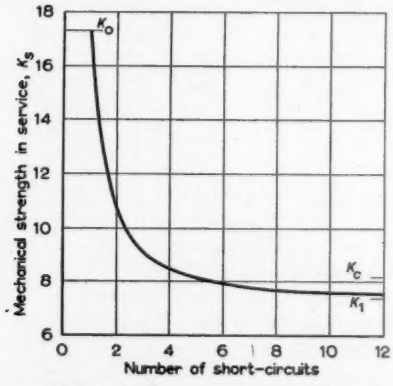
is likely to become more serious. Apart from the increase in transformer size, the severity of short-circuits is increasing owing to larger system capacities. The short-circuit current permitted by system planning engineers is generally based upon the rupturing capacity of circuit-breakers and this has increased during twenty-five years from 1 500 MVA to 25 000 MVA or more. Since mechanical stresses depend on the square of this current, the increase may well be alarming.

A much more serious aspect is that mechanical stresses are cumulative, and the mechanical strength will thus



1 *Hydraulic press used for study of stress/strain relations of complete windings*

depend upon the frequency of short-circuits. Final failure may not necessarily be due to a severe fault but may be the cumulative effect of many earlier faults, the final one being the last straw, as it were, and not necessarily severe in itself. The dependence upon frequency is serious, because two recent developments in supply-system operation seem likely to increase the number of short-circuits in service. These are the practice of auto-reclosing, which makes repeated switching onto possible faults a normal practice, and the introduction



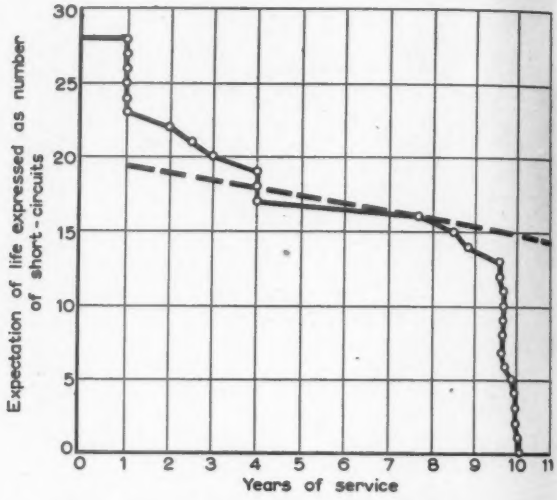
2 *Relation between mechanical strength and number of short-circuits*

of fault throwing for intertripping purposes, where short-circuits are deliberately created under normally controlled conditions.

The three principal forces in a transformer are radially repulsive, axially compressive and axially repulsive.

The mechanical strength K is defined as the ratio of the r.m.s. value of the asymmetrical short-circuit current to the full-load current. It will have a separate value for each individual force.

The internal compressive force in each winding causes



3 *Service record of short-circuits on 30 MVA transformer*

Broken line indicates normal operating conditions, which would lead to 54 years of service.

maximum stress in the middle of the winding and thus does not involve the coil supports. This is not usually serious, and since it is independent of design or construction the resulting strength is termed the ideal strength K_i.

The axial repulsive forces are due to electromagnetic dissymmetry caused by tappings and other design limitations and also to unavoidable irregularities in assembly. This initial displacement gives a strength K_0, and this is the strength for a single short-circuit such as is specified in various standard specifications.

However, the winding insulation is compressible, so that the first short-circuit will result in a slight increase in the initial dissymmetry. Since the force is proportional to this dissymmetry it will be greater for the second short-circuit and this will further increase the dissymmetry.

This sequence continues with succeeding short-circuits. Indeed, if the increase in force due to displacement exceeds the compressive resistance of the windings, the condition is unstable, and the force will go on increasing until failure occurs, irrespective (theoretically) of the mechanical strength of the windings or their supporting structure. Hence, a transformer perfectly

designed and constructed, so far as mechanical support and electromagnetic balance of the windings are concerned, will not have an infinite mechanical strength but only a critical value K_c.

Since the transformer will have some initial dissymmetry the ultimate strength in service will be neither K_i, K_0 nor K_c but some still lower value K_1. In the paper the author gives a simple relation for this ultimate strength K_1.

A typical set of values for these various strengths is:

K_i	K_0	K_c	K_1
15·2	12·9	7·4	6·4

This analysis shows the behaviour of the winding under short-circuit stresses but gives no indication of the end-point, i.e. the breakdown value. This can be studied only by tests, preferably full-scale, on stacks of coils built up exactly as in practical assembly of the transformer. Manufacturers have doubtless made such tests for their own use, but the paper gives the first published information of this kind.

Fig. 1 shows the experimental arrangement for measuring the characteristics of a winding. Fig. 2 shows a typical curve of the relation between the empirical mechanical strength K_s and the number of short-circuits before failure, i.e. the life expectation of the transformer.

It is generally believed that the mechanical strength of a transformer is determined by the crushing strength of the coil supports and the electromagnetic balance of the windings. The analysis shows that whilst this is true for a single short-circuit, as in a short-circuit test, the life of a transformer in service is determined more by the compressibility of the winding insulation.

Service records of transformers known to have failed mechanically in service have been examined and analysed in accordance with the methods here described.

One particular transformer had passed through two periods of abnormal operation with the results given in Fig. 3. This shows that the transformer had a normal life of 54 years. It used up 19·3 years in the first 3·5 years of actual service and 31 years in the last 2·5 years. This is, of course, an unusual example, but it illustrates clearly the method of predicting the expectation of life when the operating conditions are known.

This and other examples given in the paper show that recent developments in large-scale power supply have made the mechanical strength of the transformer and its expectation of life a matter of serious concern.

621.314.2 : 621.3.014.3

SYNOPSES OF PAPERS

The following are synopses of papers published in the *Proceedings* which have not been read at an Institution meeting and which have not been described under 'Short Reviews of Papers'. They are included here primarily for reference. The papers have not been published individually, as those for reading at meetings, but reprints of them will be available shortly (see p. 228).

Ladder Lines

A synopsis of a Radio and Telecommunication Section paper (No. 2294) entitled 'A Theoretical Study of Propagation along Tape Ladder Lines', by P. N. Butcher, Ph.D. The paper was published in March 1957 in Part B of the Proceedings.

DISPERSION CURVES ARE CALCULATED FOR SINGLE-RIDGE, double-ridge, single T-section and double T-section ladder lines in which the rungs of the ladder are thin tapes. Each structure is broken up into several regions having simple geometries. In each region the electromagnetic field is expanded as a series of suitable wave functions. Matching of the fields at the boundaries of the regions leads to an infinite set of homogeneous linear equations for the coefficients in the expansions. These equations have a non-trivial solution only if the determinant of their matrix is zero. The dispersion curves are obtained numerically from such determinant equations. They confirm the qualitative predictions. Throughout the analysis, the ladder is approximated by a uniform sheet which conducts only in the direction of the tapes.

621.372.2

An S-Band Coaxial Load

A synopsis of a Radio and Telecommunication Section paper (No. 2310) with the above title by L. W. Shawe, B.Sc. The paper was published in March 1957 in Part B of the Proceedings.

THE DESIGN AND CONSTRUCTION OF A COAXIAL LOAD terminated in a plug or socket of Pattern 6 in RCL322 is described. The match gives a voltage standing-wave ratio better than 0·95 over the waveband 6–11 cm and can be improved with extra care during manufacture.

621.372.43 : 621.317.3.029.64

Standing-Wave Detector

A synopsis of a Radio and Telecommunication Section paper (No. 2312) entitled 'A Coaxial Standing-Wave Detector for the S-Band', by L. W. Shawe, B.Sc., and G. W. Fynn. The paper was published in March 1957 in Part B of the Proceedings.

A DESCRIPTION IS GIVEN OF A COAXIAL STANDING-WAVE detector designed primarily for routine testing of coaxial

components over the waveband 7·9–11 cm. The detector terminates in a plug and socket of Pattern 6, RCL322, and is capable of measuring voltage standing-wave ratios up to 0·98. The design has been kept as simple as possible in order to make the instrument relatively easy to manufacture. 621.317.742.029.64

Breakdown of Electronegative Gases

A synopsis of a Measurement and Control Section paper (No. 2260) entitled 'Processes Contributing to the Breakdown of Electronegative Gases in Uniform and Non-Uniform Electric Fields', by P. R. Howard, Ph.D., B.Sc. (Eng.), Associate Member. The paper is published this month in Part A of the Proceedings.

IN THE PAPER IT IS SUGGESTED THAT FOR ELECTRONEGATIVE gases, where both ionizing and attachment processes occur, the condition for breakdown in uniform fields and the onset of discharges in non-uniform fields (with the positive electrode in the high-field region) is that the ionizing and attachment coefficients have the same value.

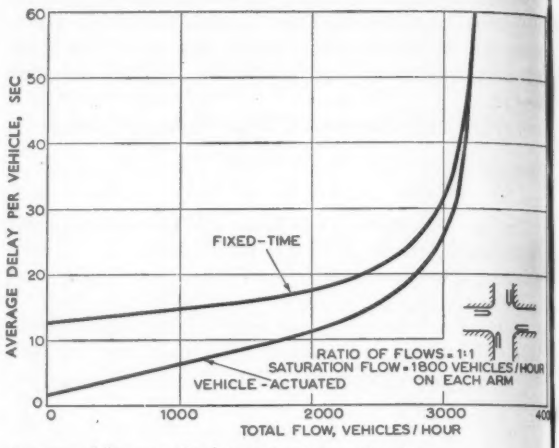
In non-uniform fields and above a certain critical pressure p_c the breakdown and discharge inception stresses coincide, but below p_c they differ. The gap processes operating in these regions are briefly discussed. 621.315.618.9.015.5 : 621.3.013

Road Transport Signalling

A synopsis of a review of progress (paper No. 2346) entitled 'The Application of Electricity to Signalling for Road Transport', by J. Stringer, M.A., and A. T. Wilford, B.Sc. The paper is published this month in Part A of the Proceedings.

THE LAST PROGRESS REVIEW ON ROAD TRANSPORT signalling appeared in the *Proceedings* in 1949. In the eight years since, which are covered by the present review, the performance of signals has improved and there have been new installations coping with more complex traffic patterns. The review is descriptive in approach and will appeal to anyone interested in road traffic problems.

The authors point out in their introduction that successful application of automatic traffic signals depends, not only on ingenious design of the electrical apparatus, but also on the correct choice of cycle timings, etc. It is not easy to ensure that delay to traffic at a busy crossing is minimized without loss of safety. An acceptable mode of operation for a traffic signal is normally found by approximate calculation, with adjustment later on site. But theoretical studies of heavily loaded intersections are now being made. The Road Research Laboratory has calculated the average delay to vehicles in terms of the various parameters of a signal and the flow of traffic. The graph reproduced here shows one result of these calculations for two types of signal. This indicates



Average delay as a function of volume of traffic

Fixed time
'Green' time = 40 sec/phase.
Cycle time = 86 sec.
Vehicle actuated
Maximum 'green' period = 40 sec/phase.
Vehicle interval = 4 sec.

that at a heavily loaded intersection the average delay is very sensitive to the flow of vehicles.

Discussing vehicle-actuated signals, the authors state that the simplest form of signal is one catering for two conflicting traffic movements, or 'phases', i.e. one for use at normal cross-roads. The principles of these apply to systems with three or more phases. A fixed minimum 'green' period, preset in the control mechanism, can be extended by a vehicle striking the detector, the increase varying with the speed of the vehicle. A maximum setting prevents a stream of vehicles holding the right-of-way indefinitely. In present equipment the 'amber' and 'red-amber' periods are controlled by a common timer; they may be concurrent or sequent but they cannot overlap. New equipment will contain separate timers, so permitting overlap. The authors discuss 'all red' periods and their control by 'extending' detectors placed in the middle of an intersection or along a narrow bridge or tunnel.

Section 3 of the review deals with provision for pedestrians and includes some details of flashing Belisha beacons. Technical features of the control equipment of a vehicle-actuated traffic-signal installation are then described, and this is followed by accounts of the complex traffic-light systems in Oxford Street and at the Monument in London.

After considering road signalling at level crossings, the authors turn to American and Continental developments. A pilot radio control system was introduced in Chicago

in 1955 and will soon be followed by one in Los Angeles. It enables the timing of all traffic signals to follow a prearranged pattern variable with time of day or day of the week. Radar is used in Seattle for detection of vehicles in a traffic-control system where installation of conventional detectors would have caused mechanical and operational difficulties. Radar speed-meters are also used in the United States and to a small extent in this country. In Germany, special devices are installed at difficult crossings to give priority to trams.

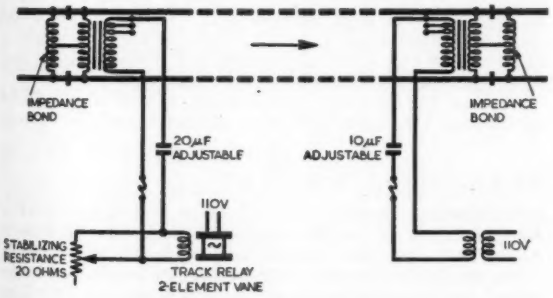
The review ends with a brief discussion of maintenance and reliability. 656.05 : 621.34

Railway Signalling

A synopsis of a review of progress (paper No. 2301) entitled 'The Application of Electricity to Railway Signalling', by R. Dell, Member. The paper is published this month in Part A of the Proceedings.

THIS REVIEW OF PROGRESS ON RAILWAY SIGNALLING covers the period from 1949 to the present day. It begins with a consideration of colour-light signals, the two types in use being searchlight signals using colour filters, and multi-lens signals having a separate lens and lamp for each colour. In discussing operation of points, the author states that the simplicity of the electro-pneumatic system has brought it back into favour. Several large installations have recently used this system rather than an electric-motor-driven one, which for a number of years had been preferred because it does not need a compressed air supply.

The next section of the review is about track circuits, and the diagram reproduced here shows a typical a.c.



track circuit employing impedance bonds for a return current. These are used where both running rails are required for the traction current return, to enable the rails to be insulated into sections, still maintaining a continuous path for the d.c. return. The capacitors are adjusted to resonate the circuit of the impedance band. Relays and cables are surveyed, and there follows an interesting section on signal-cabin control methods. The author states that the use of power operation for signal cabins has now become almost the recognized standard. Most of the larger installations are provided with thumb switches or pushbutton control for the signalman and employ circuit interlocking.

An account of automatic junction operation includes details of a noteworthy installation of this at Camden Town. Much work has been done on the system in the United States. The author then discusses briefly automatic train control, speed-control signalling and train description. He mentions also the automatic train announcer which has been installed on the Eastern Region. The review concludes with sections on mechanization of marshalling yards, and coded centralized traffic control, an interesting feature of signalling which has not yet been used on British Railways, but has made great strides recently in other parts of the world. Much of the required equipment has been manufactured in this country. C.C.T. control was originally designed for the control of the signalling of long sections of single line having passing loops, but its use has recently been extended to other purposes, including the control of reversible signalling on double lines. Train movements are safeguarded by the normal power signalling arranged beside the track. The c.c.t. system provides a medium for sending controls from a central office to operate the appropriate signals and points, and thus to determine the precedence of the trains. A coded system is also used for the return indications from the track. 621.3 : 656.25

Tubular Waveguides

A synopsis of a Radio and Telecommunication Section paper (No. 2326) entitled 'Propagation Characteristics of Low-Loss Tubular Waveguides', by Professor H. E. M. Barlow, Ph.D., B.Sc.(Eng.), Member, and H. G. Effemey, Associate. The paper will be published in Part B of the Proceedings.

TUBULAR METAL WAVEGUIDES OF CIRCULAR CROSS-SECTION supporting the H_{01}-mode and operated at a frequency well above the cut-off value for the guide are known to be capable, in ideal circumstances, of providing a screened microwave channel having an attenuation of only a few decibels per mile. The paper is concerned with the practicability of this arrangement at a frequency of 35 Gc/s employing straight lengths of copper and aluminium tubes, manufactured and installed to commercial tolerances. Using pulses of 0·1 microsec duration at this frequency, it is demonstrated that, with solid drawn tubes of standard production, attenuations about 30% above the theoretical value are readily obtainable, and the conditions of propagation are entirely stable. Arrangements for launching the wave both from the usual H_{01} rectangular-guide source and directly from a magnetron oscillator are discussed. Attention is drawn to the possible application of such a waveguide to trunk communications and to high-power transmission. Although progress has been made on the problem of propagation round bends in the guide, a really satisfactory solution has not yet been found, and further work on that aspect is in progress. 621.372.823.2.029.64

OBITUARY

RICHARD BERESFORD BURROWES

Richard Beresford Burrowes, B.SC., died at Lydd, Kent, in September 1956, at the age of 85. He was educated at Bedford and Malvern, and from 1890 to 1893 he studied physics and electrical engineering at the City and Guilds Central Technical College, gaining an A.C.G.I. He obtained practical training with the firm of Daniel Adamson and with Johnson and Phillips from 1894 to 1899. In 1900 he joined the Electric Construction Co. at Wolverhampton as a design-draughtsman, and in the years that followed held similar posts with the B.T.H. Co. at Rugby and Ferranti Ltd. at Hollinwood. He took up teaching in 1904 as an assistant lecturer at Glasgow Technical College, and some years later he patented a new type of electrostatic voltmeter. Another teaching post followed—at Battersea Polytechnic—and in 1917 he was appointed Head of the Electrical Engineering Department at the Central Technical School in Liverpool, where he stayed until his retirement in 1931. He had taken an external B.Sc. degree at London University in 1911.

Mr. Burrowes was a thorough and conscientious lecturer. He was of a rather shy and retiring disposition, and his great hobby was bird-watching. While at Liverpool he indulged in this on the shores of the Dee estuary. He also spent many holidays at Dungeness and in 1929 he began to buy land in the area to form a bird sanctuary. He moved to Lydd in 1931 and fought for many years to enlarge his bird sanctuary, raising funds, devoting much of his own money to the struggle, and even mortgaging his pension. At the time of his death over 1 000 acres of land had been preserved for birds. He was much liked by the people in the Dungeness district and was widely known as 'the bird man'.

Mr. Burrowes joined The Institution as an Associate Member in 1904 and was elected a Member in 1922.

EVAN JOHN EVANS

Evan John Evans, M.SC.(ENG.), died in his fifty-fourth year at his home at Bromborough, Cheshire, on the 5th January 1957. His date of birth was the 7th March 1903. He was educated at North Harringay Council School and at Enfield Junior Technical School, and during this time he also received private tuition. After serving his apprenticeship in the Royal Ordnance Factories at Woolwich, and studying part-time at Woolwich Polytechnic, he entered King's College, London in 1924; he obtained a B.Sc.(Eng.) degree the same year, and an M.Sc.(Eng.) degree in 1927.

In 1927 he was appointed to the Yorkshire Power Company as Assistant Engineer, and after serving in various positions he became the Technical Assistant to the Engineer and Manager in 1931. Two years later he joined the Castner-Kellner works of Imperial Chemical Industries, at Runcorn, as Deputy Manager of the Energy Division. In this capacity he was responsible to the Manager not only for the operation of the large works power station but also for the design of extensions to it. Within four years he was promoted to Manager of the Energy Division. He left Imperial Chemical Industries in September 1946 to join Lever Brothers at Port Sunlight, as Chief Electrical Engineer, where, in the post-war reorganization he was responsible for enlarging the scope of the Electrical Department. As a result he became the Company's Power Engineer. In August 1948 he was promoted to Chief Engineer of Lever Brothers, a position he held until his retirement owing to ill health in September 1956.

Mr. Evans was keenly interested in many of the social activities associated with the Port Sunlight works, being Vice-President of several of the clubs. He was well known in engineering circles, particularly on Merseyside. He was a member of the Merseyside and North Wales Electricity Consultative Council from 1949 to 1956, and was also a Governor of Bromborough Secondary School and a member of the Bebbington Rotary Club. He is survived by his widow and two sons.

Mr. Evans joined The Institution as a Student in 1928 and was elected a Graduate in 1930, an Associate Member in 1932 and a Member in 1939. He served on the Mersey and North Wales Centre Committee 1948–51 and again 1953–4, and was Vice-Chairman of the Centre 1954–6. He was Chairman-elect for 1956–7, but, unfortunately, illness prevented him from accepting the office. He was also a Member of the Institutions of Civil and of Mechanical Engineers. T. E. R.

FREDERICK THOMAS HALL

Frederick Thomas Hall, who died on the 28th July 1956, was born in 1877. He received his technical training at Derby Technical College from 1892 to 1897, and obtained practical training with J. Davis Ltd. at Derby during the same period, and later with Furse and Co. at Nottingham.

In 1898 he returned to Derby as a junior assistant engineer at the Borough Electricity Works, and in 1901 he was appointed Engineer-in-Charge at the Hampstead electricity works. The following year he moved to the City Road electricity works of the County of London Electric Supply Co., where he worked for five years.

To widen his experience and to see something of the world he went to the Kowloon Canton Railway, Hong Kong, as Assistant Mechanical Engineer from 1907 to 1908. Then he returned to England and joined the North Metropolitan Electric Power Supply Co. as a shift engineer at Taylors Lane electricity works at Willesden. After two years he was promoted to Resident Engineer at the Tottenham undertaking of the Company.

During the First World War Mr. Hall served in the Royal Naval Volunteer Reserve from 1915 till 1918, when he was invalided out of the Service, having taken part in the early landings of the Gallipoli campaign. He then resumed his duties at Tottenham, and retired in April 1930.

Mr. Hall was a Past-Master of the Civitas Lodge of Freemasons, and a founder member of the Rotary Club of Tottenham. He and his wife preferred quiet surroundings; long before the motor caravan became popular they had a horse-drawn caravan, and at one time they had houses in Cornwall and at Petworth. To their great regret they had no children. His wife survives him.

He joined The Institution as an Associate in 1899 and was elected an Associate Member in 1907 and a Member in 1912. A. H. B.

DAME CAROLINE HASLETT

Dame Caroline Haslett, D.B.E., J.P., who died at her home in Bungay, Suffolk, on the 4th January 1957, was born on the 17th August 1895. She was a pioneer who prepared the way for others by the example of her own achievements. She won people by her warm sympathy, the practical wisdom upon which her beliefs were founded, and her sense of justice. It was typical of her that at the outset of her career, when possessed of only slender means, she resigned her position rather than be forced to withdraw opinions in which she believed.

Educated at Haywards Heath County High School, she was privately coached in engineering. Her real association with the technical world began on the floor of a Scottish boiler factory during the 1914–18 War. From that time onwards her career became a part of the tradition of the electrical industry, although any recital of her appointments and activities, as engineer and administrator, cannot convey an adequate impression of her outstanding personality.

Early evidence of her ability was shown in her appointment in 1919 as first Honorary Secretary of the Women's Engineering

Society. She was the Founder, and Editor for many years, of *The Woman Engineer*. The Electrical Association for Women, which she also founded, counts itself fortunate to have been directed by Dame Caroline from its inception in 1924 until ill-health compelled her resignation in 1956. In 1930 and 1931 she was organizer, under the Board of Education, of the first summer schools for teachers on the domestic uses of electricity.

Her conviction that opportunities must be created for the employment of every talent inspired her enthusiasm for education; an enthusiasm which was made manifest through membership of the governing bodies of educational institutions such as the London School of Economics; the Queen Elizabeth College; the Bedford College for Women; and the Administrative Staff College.

Dame Caroline's concern for the welfare of the individual, man or woman, revealed itself in the extent of the public duties which she so cheerfully undertook. To mention only a few of these, she was a member of the Council of the Industrial Welfare Society and of the British Institute of Management; the first woman Vice-President of the Royal Society of Arts; Chairman of the Hosiery Working Party set up by the President of the Board of Trade at the end of the 1939–45 War; President of the British Federation of Business and Professional Women, and first British President of the International Federation of Business and Professional Women.

In 1931 she was appointed a Commander of the Order of the British Empire, and in 1947 the value of her service was further recognized by her promotion to Dame Commander of the Order.

She was made a Companion of The Institution in 1932, and she was the first woman President of the Electrical Development Association.

The apex of her life's work was reached when, in 1947, the Minister of Fuel and Power appointed her to be a part-time member of the newly formed British Electricity Authority. Her keen mind, her flair for organization, and her gentle nature contributed much to the achievements of the Authority during their early years. And all the time the generous quality of her personality was at work, influencing those she worked with far more, probably, than they realized.

Dame Caroline was taken ill over two years ago. Her undaunted courage sustained her in the hope that she would one day take up her tasks again. But it was not to be. All who knew her intimately are grateful for her life and work. Grieved as we all are by her loss, we derive some consolation from the words of the prayer spoken at the service held in her memory at St. Martin-in-the-Fields:

'Let us give thanks for the life and work of Caroline Haslett; for her integrity of mind and character; for her wide interest and good influence in many walks of life; for her sense of humour and love of simple things; for her frank and attractive personality which inspired friendship and affection. For these and all the blessings of her life we thank Thee. Amen.' C.

JULIAN WALTER SAALER

Julian Walter Saaler, who died suddenly at his home in Somerset West, Cape Province, on the 14th September 1956, was born on the 4th September 1880. He was educated in Germany at the Real Gymnasium Wöblerschule, Frankfurt-am-Main.

In 1895 he began training in the workshops of Paul Begas and Co. at Frankfurt, and in 1897 was transferred to Liegnitz and then to Thorn in Holland, to work on the installation of tramway and lighting schemes. This was followed in 1899 by one year's theoretical training at the University of Ilmenau, Thüringen, and by an eight-month spell as Resident Chief Engineer at the Mena House Hotel, Cairo. In 1901 he joined Bruce Peebles and Co. at Edinburgh, and in 1903 he was promoted to Chief Outside Engineer at the London Office of the company. After four years he was appointed Chief Engineer with the North Wales Power and Traction Co. at Llanberis, where he was in charge of the company's power station and supervised the erection of a 12-mile 15 kV transmission line to the aluminium works at Dolgarrog. In 1907 he rejoined Bruce Peebles and Co. as Engineer and Manager in Manchester, where he remained until July 1910. He was then appointed General Manager to S. Sykes and Co. in Johannesburg; this company were sole agents in South Africa for Bruce Peebles, as well as other well-known British electrical concerns. In the same year he became a naturalized British subject. Later he went into partnership with Mr. Robin Franks, trading under the name of Saaler and Franks Ltd., and became Managing Director of Saaler and Robertslid; he was the Manager in South Africa of Bruce Peebles for over thirty-four years.

Mr. Saaler played an outstanding role as engineer in the gold-mining industry and municipalities on the Rand and elsewhere. He was directly responsible for the installation of several Bruce Peebles La Cour rotary convertors for the tramway system of Johannesburg and other South African municipalities, culminating in the early nineteen-thirties in the supply to Johannesburg of units rated at 2000 kW, then considered to be a world record.

As consulting engineer to the Furness Shipbuilding Co., he was responsible for the commissioning and testing in Durban Harbour of the 4000-ton floating dock purchased from England in 1939.

At his home in Johannesburg Mr. Saaler had a well-equipped workshop, which was the envy of his contemporaries, and he often used it to their advantage and admiration since he was a first-class craftsman.

He retired to live at Somerset West, but after three years he was called in 1944–45 to supervise and effect the fabrication of the great floating dock assembled in Durban for use by the Royal Navy. The latter years of his life enabled him to indulge in his hobby of constructing electrical models in a unique workshop equipped with precision machinery of every type. He provided a beautiful sanctus bell for a local church, a lasting memorial to his craftsmanship.

One may well say of Mr. Saaler that he was a perfectionist in everything he undertook, an inspiration to those who knew him, and always ready to give kindly help and advice to his friends. He is survived by his widow.

He joined The Institution as an Associate Member in 1910 and was elected a Member in 1915. He was also a Member of the South African Institute of Electrical Engineers, of the Transvaal Automobile Club and of the Country Club, Johannesburg.

He was the author of a paper entitled 'Motor Convertors', which was read before the South African Institute of Electrical Engineers in Johannesburg in 1931. C. G. D.

HUGH CHRISTOPHER SILVER

Hugh Christopher Silver, who died suddenly on the 22nd March 1956 at his home in Epsom, Surrey, was born in Chislehurst on the 24th July 1881. His early education at Brighton College was interrupted by a severe illness (rheumatic fever) but was continued by a series of private tutors. After matriculation he began his engineering training at University College, London, under Professor Ambrose Fleming, and continued at Faraday House under Dr. Russell.

On completing his studies at Faraday House, he transferred to the laboratory staff and served for a number of years in the Testing and Standardizing Department. The experience gained furnished ideal qualifications for his next appointment as Assistant to Mr. Percy Good during the early years of the British Engineering Standards Association, being largely responsible for the Electrical Industries Section. Here he developed a flair for committee organization and management, and to these laudable activities he subsequently devoted his whole attention. It would probably be true to say that his was the hand that drafted many of the early British Standard Specifications, although he, naturally, conceded all credit for the work to the relevant committees.

With the establishment of the British Electrical and Allied Industries Research Association in 1920, Mr. Silver moved from Victoria Street to Tothill Street in order to become one of the Director's small group of 'founder' assistants. It will be seen that Mr. Silver's progression from Faraday House to the Electrical Research Association, through the B.E.S.A., formed a logical sequence that qualified him admirably for the position he held at the E.R.A. for over thirty years (1920–52).

Under Mr. E. B. Wedmore's inspired leadership, Mr. Silver, acting as Committee Secretary, took over the several co-operative

bodies interested in joint research in electrical insulation (including that set up by the Research Committee of The Institution) and welded them into a single effective body. This is still operating as one of the administrative committees that control many executive committees handling different types of research problems. He retired in 1952, in his 71st year, but in view of his many contacts he remained on call in an advisory capacity until his death.

Mr. Silver was a modest and self-effacing man, loved by many and respected by all. He was an ardent churchman, and he found relaxation in his garden as a cultivator of roses. He was twice married and leaves a widow, Dorothy.

He joined The Institution as an Associate in 1902 and was elected an Associate Member in 1907 and a Member in 1921.

W. D. O.

MALCOLM CHAMBERS TIMMS

Malcolm Chambers Timms, who died on the 23rd December 1956, was born on the 3rd June 1882. Receiving his later education at Colfe's Grammar School, Lewisham, he entered the employ of Siemens Brothers, Woolwich, at the age of seventeen as an assistant in the Core Test Department. Transferred in 1903 to the Outside Contracts Department, he worked on the North Eastern Railway electrification scheme, and from 1908 to 1916 he was Engineer-in-Charge of the company's cable contracts in Hull, after which he was sent to Australia in connection with the electrification of the Victorian Railways. His stay there lasted from 1916 to 1926, during which period he assisted with various electricity schemes and gained useful experience on extra-high-voltage cable work in both underground and submarine installations. He also wrote several technical papers and lectured to various engineering societies. On returning to Woolwich, he became technical assistant to the Cable Manager, but he resigned in 1927 to take up an appointment with the Yorkshire Power Co. as Mains Engineer on overhead high-voltage lines. In 1929 he rejoined Siemens Brothers to undertake special cable contracts abroad, and during the next few years negotiated some valuable orders on their behalf. Among these were 33 kV cable contracts for Australia (1929) and South Africa (1932), and the contract for the Bass Strait submarine telephone cable. When Submarine Cables Ltd. was formed in 1936 he was appointed Cable Manufacturing and Shipping Manager, and held this position until retirement in 1948. Employment with Preece, Cardew and Ryder followed, by whom he was retained as Cable Inspector, and in this capacity he was still actively engaged at the time of his death. Not long before his death he had also acted as special consultant to some cable makers on submarine cable manufacture, for both power and telephone installations.

Outside his profession he was interested in antiquities of all kinds and was a great lover of all things maritime, being very knowledgeable on the history of seafaring. He was also a great reader of historical works, and as a keen student of the English language he developed considerable ability as a writer. An experienced and reliable engineer, very methodical, with a clear mind and retentive memory, he was a man of fine character, courteous, kind and unassuming, and with a cheerful disposition. He leaves a widow, three sons and eight grandchildren.

He joined The Institution as an Associate Member in 1911 and was elected a Member in 1943. He was also a Member of the American Institute of Electrical Engineers.

E. A. B.

MONOGRAPHS AND PAPERS
published individually this month

Synopses of monographs and papers published individually before the next issue of the Journal are given below, and, unless otherwise stated, their dates of publication are this month. Reprints of all papers are available about two months after publication in the Proceedings. The prices shown below are post free. When ordering please quote serial number of paper or monograph. Books of 8 vouchers may be obtained from the Secretary, price 10s. each.

MONOGRAPHS

A Contribution to the Design of Multi-Element Directional Couplers *Monograph* 230 R

J. W. CROMPTON, B.E.

A multi-element directional coupler is considered as a cascaded set of 2-element directional couplers, each of which, at the design frequency, is perfect in match and directivity. A characteristic-impedance matrix and a voltage-transfer matrix may be defined for each of the basic 2-element couplers, and these are analogous to the characteristic impedance and the propagation coefficient in iterative 4-terminal network theory.

The voltage-transfer matrix is shown to be a linear function of the cosine and sine of a certain angle which is related in a simple way to the coupling factor of the elemental coupler. This function has algebraic properties analogous to those of complex numbers. In particular, the use of de Moivre's theorem is shown greatly to simplify the design of multi-element couplers.

	PAPER FOR READING	PAPER FOR PUBLICATION ONLY	MONOGRAPH
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[1] This charge includes a reprint of paper and discussion.
[2] If a reprint of paper and discussion is also required a remittance of 1s. 3d. should be sent.

Some Characteristics of Double-Exponential Pulse-Shaping Networks in High-Voltage Impulse Generators *Monograph* 231 M

G. ELLESWORTH

The influence of the magnitude of network parameters on the waveform generated by the simplest types of circuit used

in high-voltage impulse testing has been discussed at some length in the literature. These treatises are based, however, on simplifying assumptions not absolutely necessary, and no attempt appears to have been made to develop a unified approach to this problem. Moreover, some important circuits of slightly greater complexity have received particularly scanty attention, ostensibly on the grounds of mathematical complication.

The present paper introduces a unified treatment, without approximations, and with application to the more complex as well as to the simplest circuits. It indicates how one of the former may be employed to achieve higher efficiencies, coupled with increased economy of parts, particularly where resistive potential dividers are used. Some light is also thrown on the discrepancy between the nominal and actual rise-times of double-exponential impulse waves.

Distortion due to the Mismatch of Transistors in Push-Pull Audio-Frequency Amplifiers *Monograph* 232 R

K. W. GURNETT *and* R. A. HILBOURNE, B.SC.

In a Class B push-pull amplifier having balanced transformers, even-order harmonic distortion can be caused by differences in the characteristics of the two transistors. By considering the voltage gain of the two halves of the amplifier it is possible to obtain general expressions from which distortion caused by any particular characteristic can be calculated.

This paper is primarily concerned with audio-frequency amplification. It is necessary to consider harmonics outside this range because of the possibility of their giving rise to intermodulation products in the audio range.

The parameters which give rise to distortion may be divided into two categories—frequency-independent parameters, which are the only factors significant at low frequencies, and frequency-dependent parameters.

In order to obtain low distortion, some matching of transistor characteristics is necessary. Methods are described whereby matching can be achieved by fairly simple measurements. The methods used are quite general.

An Improved Design Procedure for Quarter-Wave and Direct-Coupled Microwave Filters *Monograph* 233 R

R. LEVY, M.A.

A highly accurate expression for the Q-factor of a direct-coupled filter is derived, which is analogous to that for an associated quarter-wave-coupled filter. Existing theories usually consider filters of either the maximally-flat or the Tchebysheff type, and it is shown directly, by transmission-line methods, that these are special cases of a generalized symmetrical filter. Design formulae are given for the bandwidth, pass-band tolerance, and the attenuation in the rejection band for both quarter-wave-coupled and direct-coupled generalized filters.

PAPERS

Some Aspects of Half-Wave Magnetic Amplifiers *Paper* 2353 M: *Part B*

G. M. ETTINGER

This paper deals with the properties of half-wave magnetic amplifiers having finite control-circuit resistance or rectifier reverse conductance. The analysis is based on the concept of 'reset factor', which is an exponential function of magnetic-amplifier Q-factor during the reverse half-cycle of the excitation voltage.

It is shown that the maximum power gain of a half-wave magnetic amplifier is a function merely of the ratio of unsaturated load-winding reactance to load resistance. In most practical cases, maximum gain is obtained with a small number of control turns; thus nearly all the winding space of a half-wave magnetic amplifier can be utilized for the load winding. Curves are presented which may be used to determine optimum turns ratio, optimum control-circuit resistance and maximum gain, for various combinations of control-circuit resistance and rectifier leakage.

Experimental results on magnetic amplifiers of various core materials are presented. These agree well with theory.

Consideration is given to various forms of bias for magnetic amplifiers. D.C. bias (rectifier shunting), a.c. bias and 'part-winding a.c. bias' are mentioned. Experiments with various bias circuits are described, and it is concluded that part-winding a.c. bias is to be preferred.

Date for reading not yet fixed.

British Columbia–Vancouver Island 138 kV Submarine Power Cable *Paper* 2354 S: *Part A*

T. INGLEDOW, D.SC., R. M. FAIRFIELD, B.SC.(ENG.), E. L. DAVEY, B.SC.(ENG.), K. S. BRAZIER, B.SC.(ENG.) *and* J. N. GIBSON

The authors describe the supply system of the region and the requirements necessitating the installation of a submarine power cable. They discuss the considerations leading to the adoption of pre-impregnated gas-filled cable provided with a hollow conductor and made in continuous lengths up to 16 miles. This is followed by an account of the engineering development, design, proving and performance of the cable and its accessories from the electrical, mechanical, pneumatic and corrosion aspects.

The development, design and installation of the special plant necessary for the manufacture in continuous lengths of strand, and lead-covered and finished cable, are described in the next section. Noteworthy items are large turntables for storing strand and lead-covered cable, a length-storage mechanism to link up the paper-lapping machine and the lead press for continuous manufacture, and the coiling-down shed for the storage of 90 miles of finished cable.

The transport and installation of the cable and accessories are also dealt with.

To be read on the 25th April.

The Design of High- and Low-Power Medium-Frequency Broadcasting Transmitters for Automatic and Semi-Attended Operation *Paper* 2362 R: *Part B*

W. J. MORCOM, B.SC.(ENG.), WH.SC., *and* D. F. BOWERS

The paper describes two medium-frequency broadcasting transmitters, rated at 600 watts and 100 kW respectively, and their associated combining circuits. Three of the smaller units are used in parallel to give a 2 kW station with fully automatic control, while two 100 kW sets make up the semi-attended station at Daventry. However, to conform with international limitations, the B.B.C. operates them at 75 kW each, giving 150 kW carrier power from the two units in parallel.

Similar transmitters, for both medium-wave and long-wave broadcasting, have been supplied for service outside the United Kingdom.

On the programme for the meeting on the 10th April.

TECHNICAL PUBLICATIONS

BRITISH STANDARDS

Copies of the following publications can be obtained from the British Standards Institution, 2 Park Street, London, W.1. The prices given are post free.

B.S. 215: 1956 Aluminium and Steel-Cored Aluminium Conductors for Overhead Power Transmission Purposes. 3s. 6d. PER PART.

This revision of B.S. 215: 1934 has been divided into two separate self-contained parts:

Part 1. Aluminium Conductors for Overhead Power Transmission Purposes.

Part 2. Steel-Cored Aluminium Conductors for Overhead Power Transmission Purposes.

The amendment published in 1952 to provide for changes in manufacturing technique has been incorporated into this edition, with some further modifications, and a wrapping test replaces the elongation test for aluminium wires. The procedure for sampling and testing has been revised.

Appendices give information on the strength of stranded and composite conductors and on the modulus of elasticity and the coefficient of expansion. A new feature in each part is a list of commercially accepted code names for use in ordering British Standard conductors.

B.S. 280: 1957 Field Rheostats and Rheostats for other Purposes 5s.

This is the first revision of B.S. 280 since the first edition was issued in 1928. It takes into account modern engineering practice, particularly with regard to new types of insulating material and their classification. Permitted limits of temperature rise have been related to modern insulating materials.

Other changes in the specification are a re-classification of the types of enclosure, and the introduction of a new section on service conditions. In addition, the routine tests have been amended, and type tests have been specified. There are three additional appendices.

B.S. 415: 1957 Safety Requirements for Radio or Other Electronic Apparatus for Acoustical or Visual Reproduction (Electric-Mains-Supplied) 6s.

This revised Standard deals with design, construction and electrical performance from the safety aspects only; they include protection of the user from electric shock and from flying glass (in the event of the implosion of a cathode-ray tube). Requirements limiting the temperature rise in the event of a component failure are also specified.

Attention is drawn to possible danger to the health of the user from X-rays from high-voltage equipment, e.g. from cathode-ray tubes and from rectifier valves.

The Standard requires tests to be made under 'normal' conditions and also under 'fault' conditions. The introduction of fault-condition tests is an innovation in British Standards, although it has for some years been a feature of the national regulations of some other countries.

B.S. 698: 1956 Papers for Electrical Purposes. 7s. 6d.

The first edition of B.S. 698 was published in 1936 without waiting for the results of some experimental work which was then being done by the Electrical Research Association. This work, which was interrupted by the war, has since been completed, and the Standard has been revised in the light of the conclusions reached.

The requirements of the new edition are generally similar to those of the first, but many changes in detail have been made, and, wherever possible, methods of test recommended by the British Paper and Board Manufacturers' Association have been adopted. The Standard contains some valuable appendices.

B.S. 1538: 1956 Intrinsically-Safe Transformers Primarily for Bell-Signalling Circuits. 4s.

This new edition extends the scope of the original edition to include requirements for transformers for use in applications additional to coal mining, such as the factories and oil stores where there may be risk of an explosion owing to the presence of inflammable gases and vapours.

The Standard applies only to single-phase double-wound transformers for supplying circuits which are required to be intrinsically safe as defined in B.S. 1259 'Intrinsically-Safe Electrical Apparatus and Circuits'.

Comprehensive design data and details of the constructional and test requirements are included in the specification, and additional information on design and on the measurement of leakage inductance is included in the appendices.

B.S. 1975: 1957 Primary Cells and Batteries for Intrinsically Safe Circuits in Coal Mines 3s. 6d.

The 1957 edition has been extended to include requirements for applications other than bell signalling circuits, to which the 1953 edition was restricted. It now applies to Leclanché cells and batteries of the wet and dry types, and to air-depolarized cells whose output is limited to satisfy the requirements of the Ministry of Fuel and Power.

Standard dimensions of dry cells and batteries and of the components of wet cells are specified, together with requirements for containers, current-limiting resistors, connecting wires and terminals. The approximate metric equivalents of all dimensions are included.

The purity of the zinc electrodes and of the electrolyte for wet cells is specified, and the performance requirements include details of the discharge and storage tests, together with current and voltage limitation tests.

B.S. 2817: 1957 Types of Enclosure of Electrical Apparatus 3s.

Frequently, several pieces of electrical apparatus constructed to comply with different British Standards may be grouped at the same location, and, where the same type of enclosure is appropriate or is specified by the purchaser, it is desirable that the same requirements should apply to each enclosure. Hitherto the requirements have been given in several different British Standards, and often quite unnecessary divergences have existed between them. To remedy this, the various

requirements regarding types of enclosure have been reviewed and brought together in this new Standard.

This publication deals with all the kinds of enclosure which are in common use, and comprises two parts.

Part I is a glossary giving definitions of the various types of enclosure, and Part II deals with design and construction requirements.

B.S. 2818: 1957 **Auxiliaries for Operation of Fluorescent Lamps** 6s. 6d.

The object of this Standard is to give the characteristics of the auxiliaries which are essential for the proper operation of lamps complying with B.S. 1853 (Class MCF/U). It also deals with the satisfactory and safe operation of the auxiliaries themselves. The present edition is limited to ballasts and capacitors required for the operation of 80-watt 60-inch mains-operated tubular fluorescent lamps used with starter operation on 50 c/s a.c. supplies.

E.R.A. REPORTS

Copies of the undermentioned E.R.A. Reports can be obtained from the British Electrical and Allied Industries Research Association, Thorncroft Manor, Dorking Road, Leatherhead, Surrey. The price of each report is given, and, unless otherwise stated, the cost of postage on a report is 4d.

L/T324 **A Comparison of Ionization Energies of Trapped Electrons in Ionic Solids using the Static Model** by J. H. Simpson. 6s.

The relation between the thermal and optical energies of an electron trapped at an interstitial or substitutional ion in an ionic crystal is discussed. It is shown that, for the static case, both optical and thermal ionization energies may be determined by the methods of Fröhlich (1954) and the results are compared with those obtained by another method (Simpson 1949).

L/T327 **Stabilization of Impregnated-Paper Capacitors: Further Pilot Scale Tests with Azobenzene** by H. F. Church. 15s. (POSTAGE 6d.)

This report is an extension of an earlier report (L/T268) which described life tests on stabilized impregnated-paper capacitors which had been made industrially under pilot scale conditions.

The addition of 2% of azobenzene to chlornaphthalene impregnant is found to cause a considerable extension of life of impregnated-paper capacitors under d.c. voltage at 50° C, 71° C and 85° C. Under some conditions the extension of life was up to 50 times.

The addition of 5% of azobenzene in chlornaphthalene is even more effective than 2%.

Some stabilization under direct voltage is also observed with azobenzene in petroleum-jelly-impregnated capacitors.

Under sufficiently high alternating voltage (50 c/s) very marked stabilization is observed with capacitors impregnated with chlornaphthalene containing both 2% and 5% azobenzene. This is partly an indirect effect arising from the action of azobenzene in raising discharge-inception voltage.

M/T120 **A Simple and Versatile R.F. Measuring Circuit** by J. Miedzinski and S. F. Pearce. 10s. 6d.

The impedance/frequency characteristics of components, and the transmission characteristics of filters, may be determined by means of the circuits described, which use simple apparatus readily available in the laboratory. Impedances from 10^{-2} ohm to 10^{6} ohms and the insertion loss of filters up to about 120 dB can be measured over a frequency range of 150 kc/s to 150 Mc/s. Results are obtainable to an accuracy of ± 1–2% if reasonable precautions are taken. The methods described were found useful in connection with the development of components for radio-interference suppression, and they avoided the need for more elaborate equipment. A useful feature is the ease with which the effect of power-frequency or direct-polarizing currents on ferromagnetic-cored inductors can be determined.

M/T121 **The Properties and Design of Iron-Cored Suppression Chokes** by J. Miedzinski. 24s. (POSTAGE 7d.)

The method described makes possible the design of inductors (with either positive or negative coupling between two coils) with an accuracy which is sufficient for the purpose of suppression of radio interference. The main factors limiting accuracy will be the influence of surroundings and variation in the properties of magnetic materials.

S/T94 **Lightning Protection of Tropical Transmission Systems** by R. H. Golde. 1s.

The report discusses design considerations for lines and substations. It deals with the routing for lines, protection by earth wires, shielded wood-pole lines, fully-insulated wood-pole lines, expulsion tubes, arc-suppression coils and automatic reclosing circuit-breakers.

The protection of the substations associated with such transmission lines is described, including the protective zone adjacent to the substation, rod gaps, surge diverters and protection necessary for rotating machinery.

Z/T98 **Pole-Face Losses in Rotating Electrical Machinery. A Review of the State of the Art** by K. C. Mukherji. 15s. (POSTAGE 6d.)

The losses occurring in a pole-face, solid or laminated, owing to open or semi-closed slots on the armature surface, can be resolved into two components—the losses due to eddy currents, and the losses due to hysteresis. There are of course additional losses caused by pulsations in the main magnetic circuit. Numerous attempts have been made since the beginning of the century to determine these losses, both theoretically and experimentally. A brief account is given in this report of the more important investigations, with critical comments on the methods employed and the results achieved.

O.E.E.C.

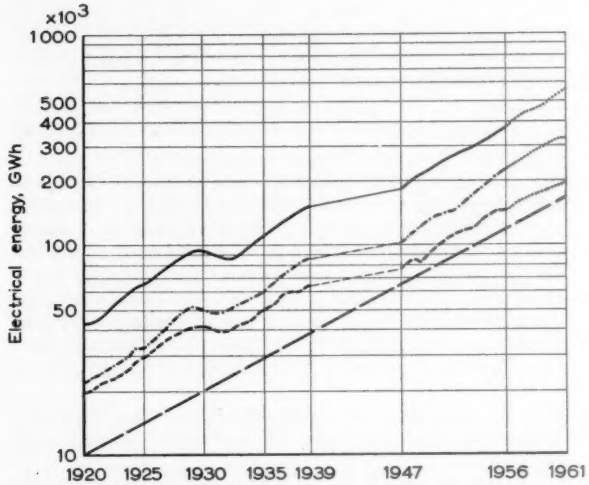
The Electricity Supply Industry in Europe 5s.

As one of the O.E.E.C. studies of economic trends, a report entitled 'The Electricity Supply Industry in Europe: 7th Enquiry Achievements and Forecasts 1954–1961' has recently been issued by the Organisation for European Economic Co-operation. Part I of the report is a general survey of the supply industry in member countries, while Part II gives detailed statistics for the individual countries.

The combined average consumption of all O.E.E.C. member countries showed an average annual increase in consumption of 9% for the years 1953–56. This is 2% higher than the increase in previous years. The total capacity of power stations rose by 7·7% in 1955, but the forecasts indicate that this rate of plant increase is likely to drop slightly over the period 1955–61. An interesting table summarizes the con-

struction programme for nuclear stations. These have been, or will be, built in Belgium, Denmark, France, Germany, Italy, Netherlands, Norway, Sweden, Switzerland, and the United Kingdom. Forecasting production for the period 1956–61, the report estimates that the combined thermal and hydro production in member countries should increase by 7·5% per year (see graph). Although hydro production should continue to increase, the estimated figures show that it will represent in 1961 only 36% of the total production, as against 41% in 1950.

Energy exchange between member countries has continued to grow. The heaviest exchange took place in Germany, which imported 2945 GWh and exported 1709 GWh. Exports of electrical energy from Sweden are estimated as increasing from 188 GWh in 1954 to 500 GWh in 1959.



Increase of electricity production in the O.E.E.C. countries

——— Total production. — — — — Hydro production.
—·—·—·— Thermal production. ..... Estimated.
—— —— —— Slope showing doubling every ten years.

Electricity Rates: Administrative Regulations Concerning the Supply of Electricity 7s.

A report prepared by a group of experts of the Organization for European Economic Co-operation surveying the administrative regulations governing electricity rates in O.E.E.C. countries has recently been issued. The first part summarizes the essential aspects of the regulations in force in the various countries, while the second part considers each country's regulations in fair detail, and this includes a useful summary of the position in the United Kingdom at the end of 1956.

The above two publications are obtainable from the O.E.E.C., 33 rue de Franqueville, Paris, 16e.

TECHNOLOGY

A new 'monthly review of training and education for industry and commerce' was born last month. Its name is *Technology* and it costs 1s. per issue; the publishers are the proprietors of *The Times*. One of its chief aims is to provide a platform from which industrialists may make known what they are looking for in Britain's expanding programme of technological education. Equally it will offer a platform to the teacher to give his views on the teaching of technology. To quote from the first leading article:

> As the newspaper of an expanding partnership *Technology* will seek each month to keep all its branches informed of what each is attempting. It will treat management and design as essential, in their different ways, to good manufacture. It will indicate to those responsible for guiding young people the industrial careers which are most in need of able recruits. But *Technology* is no more than the voice of a movement. Its inspiration can come only from those industrialists and teachers who are keenly concerned and are its potential contributors and correspondents.

Electrical engineering is well represented among the contents of the March issue, for there are articles on 'Futures in Electrical Engineering' by Dr. Willis Jackson and on 'Liquid Metal Pumps in Nuclear Industry' by Professor G. H. Rawcliffe. Dr. Jackson discusses the increasing need for more technologists caused by nuclear and other electrical developments. Other contents include an admirably written and interesting commentary on this and that; an article on French apprentice training; a note about the new technological sandwich courses; two illustrated pages comparing new scientific buildings in England and in Aachen; a note on women's mathematics at Oxford; 'Industrial Roundabout'—brief items of industrial educational news; correspondence; 'Around the Colleges'; and book reviews.

Believing that it is 'not a bad thing, in a paper given over to preparation for hard-working lives, to pay a little attention to some of the pleasures which are hard work's rewards', the editor has included in *Technology* sections on television, theatre, cinema and opera—all most readable. However, these reviews are not quite addressed to the engineer off duty, for in three of them the technical link is present. The first lightly discusses the absence of technological television programmes; the second reviews the Borough Polytechnic's production of *The Clouds*, regretting wistfully that some electrical engineering students were not in the cast; the fourth treats of opera production at the Cambridgeshire 'Tech'; only the third reviews entertainment with no strings attached—films generally released in March, including *The Silent World, Baby Doll, Oklahoma* and *Ill Met by Moonlight*.

Technology is printed as a newspaper, with an ample sprinkling of photographic and line illustrations. It uses a slightly longer page than *The Times Science Review*, and type that is on the average both larger in size and more generously spaced. It is in fact visually inviting. But some readers may think the daily newspaper's trick of printing the first paragraph or two of an article in larger type than the remainder to be out of place.

All engineers will surely welcome *Technology* and wish it good-luck. As Dr. Venables writes in a letter published in the first issue, 'The appearance of a journal devoted to the needs of technical education is a matter for congratulation and hope, even in a world smitten with a multiplicity of journals.' But we should not forget that the prime requirement for technological education in Britain to-day is not more discussion. It is more action—by many people, from the Minister to the schoolmaster. The public too must change its outlook on technology. This will not be achieved by preaching to the converted in either *Technology* or the *Journal of The Institution of Electrical Engineers*. Let it be said that the national Press could help more over this than it does at present; the proprietors of *Technology* might well consider whether some of the arguments that are being advanced in it could not more fruitfully find their way into the pages of its parent newspaper.

**Denotes that the publication is also in the Lending Library. The publications cannot be bought through The Institution; the publishers and the prices are given only for the convenience of members.*

LIBRARY ACCESSIONS

BOOKS

HAGUE, B. 621.317.33

Alternating Current Bridge Methods. For the measurement of inductance, capacitance, and effective resistance at low and acoustic frequencies*

5th ed. (revised). London, Pitman, 1957. pp. xviii, 650. 22×14 cm. £3.

This is a reprinting of the fifth (1943) edition of this well-known work. Certain errors have been corrected, and fundamental principles have been stated in terms of M.K.S. units. The extensive supplementary notes have been augmented to bring them up to date.

HOLLAND, L. 533.59

Vacuum Deposition of Thin Films*

London, Chapman and Hall, 1956. pp. xix, 541. 22 × 14 cm. £3 10s.

A comprehensive work which discusses the design and use of apparatus for producing thin films by vacuum evaporation, and by sputtering. The electrical and optical characteristics of thin films are described with particular reference to the mode of film formation.

INGRAM, D. J. E. 535.34

Spectroscopy at Radio and Microwave Frequencies

London, Butterworth, 1955. pp. xii, 332. 22 × 13 cm. £2 5s.

A critical review of the techniques which have been developed and the main applications. The frequency range is from 1 to 500 000 Mc/s, and gaseous microwave spectroscopy, ferromagnetic and paramagnetic resonance and nuclear radio-frequency resonance are all considered. The design of experimental apparatus and equipment is dealt with in some detail.

IVALL, T. E. (Editor) 518.5

Electronic Computers. Principles and applications*

London, Iliffe, 1956. pp. viii, 167. 22 × 14 cm. 25s.

An explanation of the principles of analogue and digital computers which will be readily followed by anyone with a modest understanding of the behaviour of thermionic valves. The electronic circuits used for achieving specific operations, such as addition, multiplication, integration, and storage, and the construction of complete machines of varying complexity, are explained. Then applications, especially to automation techniques, are described and probable future developments discussed.

JONES, E. B. 681.2

Instrument Technology Vol. II. Analysis Instruments*

London, Butterworth's Scientific Publications, 1956. pp. xi, 208. 28 × 15 cm. £2.

Volume one deals with instruments for the measurement of pressure, level, flow and temperature. This volume deals with instruments for analysis. It discusses sampling systems, the measurement of density or specific gravity, humidity, and instruments for chemical analysis. A third volume is to deal with telemetering and control instruments.

KIMBARK, E. W. 621.315.01

Power System Stability. Vol. III. Synchronous Machines*

London, Chapman and Hall, 1956. pp. ix, 322. 23 × 15 cm. £4.

Vol. I is an introduction to the calculations involved in stability problems and Vol. II covers power circuit-breakers. This volume deals with the theory of synchronous machines and their excitation. It discusses saliency, damping, and saturation and extends the treatment of each of the other two volumes. This book will be reviewed in a future issue.

KINNARD, I. F. 621.317

Applied Electrical Measurements*

London, Chapman and Hall, 1956. pp. vii, 600. 23 × 15 cm. £6.

Intended as a reference work on the principles of the electrical measurement of electrical and non-electrical quantities. A short review of the history of the subject is followed by a discussion of the theory of measurement. The non-electrical quantities are considered under the headings of light, heat, sound, time, liquids, gases, and mechanical quantities—the latter including force, strain and thickness. The book includes many sketches and circuit diagrams, bibliographical references to each chapter, and a detailed index.

KIVER, M. S. 621.314.7

Transistors in Radio and Television*

London, McGraw-Hill, 1956. pp. vii, 324. 23 × 15 cm. 37s. 6d.

A non-mathematical description of the various types of transistor and their applications in radio receivers as oscillators and amplifiers.

KONDO, K. (Editor) 538.551

Memoirs of the Unifying Study of the Basic Problems in Engineering Sciences by Means of Geometry. Vol. 1

Tokyo, Gakujutsu Bunken Fukyu-kai, 1955. pp. xv, 590. 26 × 18 cm.

First report of a group of research workers concerned with applications of tensors to problems which include electrical networks.

KRETZMANN, R. 621.38

Industrial Electronics Handbook*

2nd ed. London, Cleaver Hume, 1956. pp. xi, 298. 23 × 15 cm. £2 2s.

Originally published in 1953 as 'Industrial Electronics' this enlarged edition, brought up to date, is now thought to justify being called a handbook. It deals first with the principles and properties of electronic valves and similar devices, then with counting and control circuits for various industrial purposes.

LANG, D. G. 621.396.96

Marine Radar*

London, Pitman, 1956. pp. xiii, 229. 19 × 13 cm. 30s.

Written for those concerned with the maintenance of ships' equipment, it explains the theory and principles of operation including the circuits employed in radar receivers, the cathode-ray tube and transmission lines. Details of well-known commercial equipment are then given, and the performance of receivers including spurious effects and other faults are discussed.

McLACHLAN, N. W. 517

Ordinary Non-Linear Differential Equations in Engineering and Physical Sciences

2nd ed. Oxford, Clarendon Press, 1956. pp. viii, 271. 24 × 16 cm. 35s.

A practical introduction to non-linear equations. Indicates by examples how certain types of problems in engineering and physics may be solved and how experimental results may be interpreted by non-linear analysis. This edition includes some additional material on differential equations.

SOME RECENT BOOKS

L. B. ARGUIMBAU and **R. D. STUART**
FREQUENCY MODULATION

LONDON: METHUEN. NEW YORK: JOHN WILEY. 103 PP. 8s. 6D.

C. E. TIBBS and **G. G. JOHNSTONE**
FREQUENCY MODULATION ENGINEERING

CHAPMAN AND HALL. 447 PP. £2 5S.

Mr. Arguimbau and Mr. Stuart's little book is yet another in the excellent series of monographs produced by Methuen on physical subjects. The authors worked for a time together in the Research Laboratory of Electronics at the Massachusetts Institute of Technology, and Mr. Arguimbau will already be familiar to some readers as the author of 'Vacuum Tube Circuits and Transistors'.

A brief introduction to the subject of frequency modulation is first given; in this there are a historical survey and a short introduction to the improvement afforded in signal/noise ratio by the use of frequency modulation. The next chapter deals in detail, in a beautifully concise and logical fashion, with 'The Nature of Frequency Modulation'. By merely reading this chapter, the student should obtain a clear impression of the fundamentals underlying frequency modulation.

Chapter Three deals with transmitters, several different types of modulator and frequency-control system being described. The next two chapters discuss receivers and interference respectively, the emphasis once more being on principles rather than detail. Almost all the receiver chapter is devoted to discriminators, and it is perhaps regrettable that some short mention was not made of some of the more difficult practical problems of f.m. receivers, such as the problem of local-oscillator stability.

The last chapter deals with applications of frequency modulation to television; one wonders why this chapter was included. Apart from link equipment, the use of frequency modulation in the vision side of television is largely academic and hardly worthy of mention.

The student can do no better than read this excellent little book in order to gain a sound background and working knowledge of the subject.

Mr. Tibbs's well-known and very readable book has been revised and brought up to date by one of the younger experts in this field, Mr. Johnstone of the B.B.C. Additional chapters are included on interference, aerials, and receivers in general. After an excellent introduction to the student on the principles underlying time modulation of radio waves, the relative merits of amplitude, frequency and phase modulation are discussed. The scope of the book includes interference and its suppression, propagation of f.m. waves, polarization, aerials, f.m. transmitters, a receiver section dealing in detail with limiters and discriminators, and two final sections on measurements on f.m. equipment and other practical uses of f.m. waves.

Although the chief appeal of this book will be to students, the qualified engineer will find much useful information on circuits and valves in general use to-day. The information is well set out and alternative forms of the same circuit are invariably given, with the merits of the variants pointed out.

We may wonder why Mr. Johnstone, in bringing this book up to date, chose two American receivers of relatively old design as 'typical f.m. receivers'. Surely the recognized experts in the receiver field are by this time the Germans, but scant reference is made to any of their work in the text. A similar startling omission is lack of emphasis on the importance of the prevention of spurious radiation from the local oscillator in f.m. receivers. At some not-too-distant date the problem of interference caused by f.m. receivers to Band III television may be most serious, unless steps are taken now to prevent such effects.

'Frequency Modulation Engineering' is well presented and the authors are to be complimented on the labelling of the illustrations and diagrams. The book is a useful addition to any engineering library or bookshelf.

K. McILWAIN and **C. E. DEAN** (*Editors*)
PRINCIPLES OF COLOR TELEVISION

NEW YORK: JOHN WILEY. LONDON: CHAPMAN AND HALL. 611 PP. £5 4S.

This 600-page American book covers the principles underlying modern simultaneous coded-signal colour television. The fundamentals are very fully explained and space for technological considerations is therefore rather restricted. Excluding the glossary, the appendices and the indexes, seven chapters are devoted to colour physics, optics and colour vision, and ten chapters to electronics, including coding, decoding, synchronization, displays, methods of testing colour equipment and the inescapable account of the colour-television standards of the Federal Communications Commission. The space allotted to colour physics is perhaps greater than that to be found in other similar works, but this is undoubtedly justified in view of the poor training which many physicists and most engineers have received in colorimetry and allied subjects.

The book is a compendium of a set of reports issued by the Hazeltine Corporation of America between 1952 and 1955. As would be expected, its technological treatments are more detailed for subjects to which major contributions have been made by the Hazeltine Corporation than for discussions of contributions by other organizations. Thus colour synchronization is well covered, although the mathematically inclined reader will wish to refer to Richman's treatise in the *Proceedings of the Institution of Radio Engineers* (1954, 42, p. 106). On the other hand, the subject of dynamic convergence of the beams of a three-gun display tube is dismissed in a couple of sentences, and the complicated circuits required to produce the necessary waveforms at line and field frequencies are replaced in the relevant diagrams by block schematics which make no attempt at explanation. Again, the discussion relating to the double-triode high-level colour-difference signal demodulator adequately explains the principles upon which the method relies, but makes no attempt to help the reader to understand how the green colour-difference signal is extracted from the common-cathode-load circuit of the demodulator triodes for the red and blue colour-difference signals. An interesting decoding circuit is referred to as the

'sub-carrier matrix', but no reference is given to further work upon it.

Although present-day colour-television receivers make exclusive use of three-gun displays, the book very wisely devotes only three pages less to decoders for one-gun displays than it does to those for three-gun displays. The principles of decoding and operating 'apple-type' beam indexing tubes are discussed.

The book is the result of the contributions of twelve eminent engineers and physicists and may therefore be regarded as an authoritative treatise on the subject. It will be found to be most suitable for graduate engineers wishing to prepare themselves for design and executive work in connection with modern colour television. At a price of over five pounds the book cannot be regarded as cheap, but in view of the extensive ground covered it is not unreasonable.

C. R. MASON

THE ART AND SCIENCE OF PROTECTIVE RELAYING

NEW YORK: JOHN WILEY. LONDON: CHAPMAN AND HALL. 424 PP. £4 16s.

This book is written by an American engineer with long experience in the design and manufacture of protective relays and associated equipment. It deals entirely with American practice. There is no reference to any British practice nor to British publications, and on that account it might be considered unsuitable as a textbook for the practising protective-gear engineer and advanced student in this country. This is not so, however, for the author covers the basic principles of protective relaying and describes various schemes in a way that is universally acceptable.

A section deals with the basic equations for various forms of relay construction, such as attracted-armature, shaded-pole, induction-cup and -disc, beam and moving-coil. The reader is therefore given a picture of the field in which the various forms are suitable and of their limitations.

There is a section on a.c. pilot-wire relaying, covering circulating current and opposed-voltage principles. The schemes described are very similar to those which have been developed in this country during the last ten years. The phase-comparison principle is applied only to carrier or microwave schemes and has not been used for busbar and pilot-wire schemes as in this country.

Two sections are devoted to current transformers and voltage transformers, and much useful information is given, although some is applicable only to American practice.

Distance relaying is well described, bringing in recent developments such as the mho relays, directional-control and memory action. The R/X diagram is introduced in a section on 'Methods for Analysing, Generalizing and Visualizing Relay Response'. Reference is made to phase-sequence filters and to the place for polyphase and single-phase directional relays.

The generator-protection schemes which are described are those used in America, but they are not dissimilar to schemes used in this country. All aspects are well covered, including protection for open-circuits, stator and rotor over-heating and prime-mover over-speed protection. The section on motor protection is only a short one, but it covers schemes for short-circuit protection, protection against turn faults and rotor over-heating.

Transformer protection for all types includes schemes for parallel transformers and combinations of generator, main transformer and unit transformer. The cause and effects of magnetizing-current inrush are described, and ways are suggested of compensating for it in relay designs. Even Buchholz protectors are discussed, although these devices are little used in America at present, since most transformers have no conservator vessels.

A section is devoted to busbar protection, which includes descriptions of frame-leakage schemes, directional-comparison schemes, partial-differential schemes and voltage-differential schemes using linear impedance. Some of these schemes are not used in Britain.

There are three useful sections on line protection, dealing first with simple schemes of time-graded induction-type over-current relays and then the improvements in discrimination obtained by adding directional and high-set instantaneous over-current relays. The various forms of earth-fault and parallel-feeder protection are described. Schemes with a.c. circuit-breaker tripping for distribution circuits are discussed. In the description of line protection with distance relays, a chapter is devoted to the choice between impedance, reactance or mho relays, and most aspects of distance relaying are adequately covered. Reference is made to electronic distance relays, which have been the subject of recent Institution papers. Schemes of line protection using various forms of communication channel are described. Finally, attention is drawn to an electronic directional-comparison equipment which has been recently constructed and which is claimed to operate in one cycle, foreshadowing things to come.

A very good bibliography is given at the end of each section, although, as mentioned above, it refers only to American publications.

F. SCHRÖTER and others

FERNSEHTECHNIK ERSTER TEIL: GRUNDLAGEN DES ELECTRONISCHEN FERNSEHENS (TELEVISION TECHNIQUE PART I: FUNDAMENTALS OF ELECTRONIC TELEVISION)

BERLIN: SPRINGER-VERLAG. 785 PP. £7 15s. APPROX.

The book is the first part of Section 5 of a monumental work covering the whole of the radiocommunication field, edited by Korschenewsky and Runge, and dealing with the theoretical foundations of television. The second part will deal with transmission, propagation and reception. The book is divided into ten self-contained chapters. A historical introduction and explanation of basic principles, leading to the choice of the present universally adopted scanning system, form the first chapter. The second deals with the physiological and psychological foundation of human vision, persistence of vision and acuity, adaptation, flicker, colorimetry and the main principles of colour television. The fundamentals of image analysis, treated in the next three chapters of more than 250 pages, comprise the one-dimensional theory of image structure, scanning by apertures of various shapes, frequency bandwidth and transient response, reproduction of short and long rectangular pulses, vertical resolution, general scanning systems and special methods like crispening and dot-arresting systems, Kell factor and optimal choice of number of lines for a given bandwidth, the two-dimensional theory of resolution, analysis of the energy spectrum of a modulated television carrier, d.c. transmission, scanning-aperture shape and size, etc.

The sixth chapter is devoted to energy-transfer processes, i.e. to the physics of light and electrons, photo-electric phenomena, photocathodes, spectra, secondary electrons,

emission and multiplication, semi-conductors, Kerr effect, physics of gas discharges and of luminescence, cathode-ray beams and phosphor screens. The first six chapters are edited by Professor Schröter.

The remaining chapters deal with the fundamentals of electron optics, electron lenses and their characteristics and aberrations, deflection and immersion systems, principles of conventional cathode-ray tubes and of post-deflection tubes, pick-up devices such as flying-spot scanners, and the storage principle applied to the various well-known camera tubes, followed by image reproducers such as direct-viewing tubes, projection systems and various colour tubes. The appendix contains brief accounts of standards and tolerances adopted in television transmission systems, of the principles of synchronization and deflection, and of problems of immunity from noise and interference.

The book contains 632 illustrations, ten separate bibliographies and an object index, and is produced to the high standard expected from the publishers. The mathematical treatment is exact but should not prove difficult to advanced students and telecommunication engineers; on the other hand more than a superficial knowledge of technical German is required to follow the concise style of the book.

One minor criticism may be raised: in a work of so high a standard one would expect the several reproductions of the colour triangle to be printed in colours.

Of particular value is the fact that, despite the immense amount of quoted and discussed work by television experts (from Britain, the United States and the Continent), the work is much more than a handbook and is distinguished by a uniformly high standard of critical analysis.

It is beyond doubt by far the most thorough and balanced book published so far on the subject, and its translation into English is most desirable.

Elections and Transfers

The following elections and transfers approved by the Council are effective from the 10th January 1957.

ELECTIONS

Graduates

APPLEBY, Allan
ASHWORTH, Harry
AVORY, Leslie Edward
AXON, John
AYLESBURY, Nigel Lester, B.SC.(ENG.)
BAKER, William Herbert
BARNARD, Thomas Alwyn
BECKMAN, Donald Hubert
BELL, Donald
BELLAMY, Ronald Samuel
BENNETT, Gordon
BISHOP, Donald Edwin
BLAKISTON, Peter Thomas
BOOTH, Arthur Albert
BRANTHWAITE, Raymond
BROWN, Robert Maurice Edward
BUNDY, Douglas Ernest
BURDETT, Joseph
BURROWS, Albert John
BUSH, Kenneth George
BUTCHER, Ernest Harry
CAMPBELL, Henry Farrell
CAMPBELL, Lawrence Alexander, B.E.
CHILTON, Roy Henry, B.SC.(ENG.)
CLAROS-RADA, Javier, Dipl.Ing.
COATON, James William
COLLIER, Christopher Robert, B.SC.(ENG.)
COLLS, John Stanley
CONNOLLY, John Francis
CORBEN, Peter Mervin
CROWTHER, Geoffrey, B.SC.
CURRIE, Ronald
DAVIES, Anthony Gilbert Tarrier, B.SC.(ENG.)
DAVIES, David Wyndham
DAWSON, Ronald Peter
DEACON, Michael
DICKENS, George Middleton Oliver
DRAIN, John William
DUBBER, Walter Edward Archibald
DUFF, Ian James
DURRANDS, Kenneth James
EASTERBROOK, John Edgar
EDGINGTON, Gilbert Frederick
EDGLEY, William
ELLISON, Lawrence Roy, B.E.
ENFIELD, John David, B.E.
ENRIGHT, William Henry
EVANS, Eric James
FAUL, John Peter
FEETENBY, Conrad
FLEMING, Derek William
FLOWER, Sydney
FOX, John Brian
FRYER, Derek Harry
GILES, Norman Sydney
GOMM, Frederick William John
GOWING, Bernard
GROVER, Dennis John
HAIGH, John Ambrose
HALL, William Frank James
HALLIDAY, Rowland
HAND, Arthur
HARKER, Dennis
HARLEY, George David
HAYWARD, Charles Michael
HEWSON, Raymond
HILL, Stanley Joseph
HOOTON, Albert Shepherd
HOPKINS, Leonard John, B.SC.(ENG.)
HUDSON, Roy Douglas Herbert
HUFF, Robert Stanley
JEFFERY, Stanley Leonard
JONES, John Wyn
JONES, Kenneth
JONES, Stanley John
JONES, Thomas Denzil
JOWETT, Robert Ian
KEENAN, Kevin
KING-MOLONY, Pierce, B.E.
KINMAN, Arthur Norman
KIRK, Lawrence James
LEECH, Norman Edward
LEWIS, Raymond James, B.SC.
LINTURN, Edward James
LITTLE, John Desmond
LLOYD, David John, B.SC.(ENG.)
LÖBERT, Otto Friedrich, B.E.E.
LONG, Gordon Herbert
LUMLEY, George Oyston Nicholson
LYON, Gerald William
MCILWRAITH, John Wallace Breckenridge
MCKEE, Hamilton
MCKEER, Raymond Ernest
MCTERNAN, John Denis
MANN, Eric John
MANN, Jack Bert Arthur
MANNING, Ronald George
MAPLESDEN, Leonard James Frederick
MARSHALL, John Herbert
MARVELLY, Bernard John George
MAUDE, Charles Alan
MELLOR, Derek Lawrence
MELLOR, Eslyn Roy
MILLER, George Arthur Lewis
MILLS, Dennis John
MITCHELL, Trevor
NASH, Brian James
NEWELL, Joseph
NICOLL, Henry Ernest
OAKLEY, Ronald Arthur
ORR, Euan Rannoch
PITKIN, Sydney Richard, B.SC.
POCOCK, Alan
POMFRET, Alan
POOL, John
PRICE, David Arthur
REDMAN, Ernest
REED, Idris Charles Harkless
RICHARDS, Charles Donald
ROBERTS, George William
ROBERTSON, James Birnie
ROBINSON, Ernest Henry
RODKIN, Nathan
ROSE, Milton, B.SC.
RUDGE, Peter Joseph
RUMBOLD, Arthur Gilbert
SCOTT, Geoffrey Charles
SEN, Satyaban
SHARMAN, Anthony Thomas
SHORE, Kenneth
SKELTON, Ronald Leonard
SLATER, James William
SMITH, John Douglas
SQUIRRELL, Ronald Walter
STABLES, Ronald Leslie Thomas, B.SC.
STANNARD, Gordon Peter
STUMP, Edward Robert
TAYLOR, Geoffrey Norman
THOMAS, John Powell
THOMPSON, Christopher Allan
THORNE, Kenneth John
TIMMS, George Edward
TITTEL, Klaus Frank, B.A.
TODD, Malcolm
VALENTINE, Gerald, B.ENG.
VANICHSENI, Sukind, B.SC.
VICKERS, Frank
VIGOR, Harry Allan
WARD, Eric Ernest
WATERMAN, Anthony John
WATSON, Victor Arnold
WHITEHOUSE, Stanley Gordon
WHITTAKER, Alec
WICKES, Patrick
WILKINSON, Alan
WILKINSON, John Frederick
WILLIAMS, Eifion Rogers
WINYARD, Alexander David
WOOD, Norman
WRIGHT, Desmond Louis

Graduates (contd.)

Students

ALEXANDER, James Bremner
ALLEN, Ronald Walter
ALMUNSHI, Hamid Sadik Ridha
ANDREW, Robert Meriton
BATTY, Alan Charles
BEASTALL, Harry Rex
BLISS, Frank Henry
BOARDMAN, Ian Richard
BOOTH, John Trevor
BUCKTON, Colin James
BUTT, Roger Gueriott
CALAZ, Robert Arthur
CAPSIMALIS, George Constantine
CARTER, Robert Alan
CHAMBERS, John Ernest
CHATWIN, John Arthur
CHESTERS, Anthony Hugh
CLARIDGE, John Michael
CLARKE, Roy Wellesley, B.SC.
CLARKSON, Donald
COPE, Michael William
COWARD, Philip Ronald
CROSSINGHAM, Ian Henry
CRUTCHER, Peter Sidney Charles
DAVIS, Roy
DIMANBRO, Peter Henry
DOBSON, Jack
DUXBURY, Frederick Grunwell, B.SC.
EBSWORTH, John Brian
EDGE, Norris Armitage
EKANEM, Richard Edet
EVES, Michael
EDWARDS, John Ronald
FANE DE SALIS, John Cecil Edmund
FARMER, Bryan Bigsby
FORSTER, Reginald
GORMANN, Edward Philip George
GREEN, David George
GREEN, Maurice
GRIFFITHS, Derrick Thomas
GRIMES, Michael
HALE, Peter
HALL, David Michael, B.A.
HANDLEY, William Robert Charles
HARKNESS, Eric Harold
HARRIS, Robert Edward
HECKLE, Desmond William, B.SC.(ENG.)
HICKS, Gordon Graham
HILTON, John William Claud
HORNE, Russell John
HUSSAIN, Salim Ibrahim
IRELAND, Bernard Sidney
IVES, Geoffrey
JEBB, Alan
JOB, John Henry
JONES, Berwyn Lloyd

Students (contd.)

KINBERDAL, Ingolf
KIRKHAM, Roy
KRICK, Martin Roger
LAMB, Norman Bruce Christieson
LAMB, Peter
LEVITT, Jeffrey
LEVY, Barrie Harold
LIGHTON, John Owen
LEWIS, Bryan Ashley
LIM, Khaik Keong
LITTLER, Albert George
LOUGH, John
LOVESEY, David Alexander
MACCORMICK, Alasdair John Anderson
MALIK, Sec.-Lt. Abdul Qayyum, B.SC.(ENG.)
MASKELL, Edward William James
MATHIESEN, Pierre Arne
MEEK, David William
MIDDLETON, Peter Alan
MONTAGUE, Anthony Earle, B.SC.
MUNIM, Sec.-Lt. Muhammad Abdul B.SC.(ENG.)
MURCOTT, Robert James
OLIVER, Brian James
ORBECK, Ivar
PLATT, John Kay
POPE, Peter James
PORRITT, Frank Lindsley
PRICE, Miss Nicholas Nadine Aitken, B.SC.
RACE, Donald Malcolm
RILEY, Paul Ian
ROBERTS, David John
SAALER, Peter Terence
SCRIVEN, Anthony
SEE THO, Kok Hong
SHAH, Sec.-Lt. Munawar, B.SC.(ENG.)
SHTEINSHLEIFER, Zvi
SIBERT, Frederick Graham
SPENCE, Thomas Mallorie
SPENCER, Neil Rewbridge
SRINIVASAN, Subramaniam
STORKEY, Robert
SWANN, James Edward
TAYLOR, David Robert Duff
TAYLOR, Raymond John
TIMMIS, Albert Gerald
TOPLISS, Richard John
TURNER, Kenneth John
VENKATARAMAN, Komaratchi Subramanya, B.SC.
VERMEYLEN, Peter Frank
WALKER, Peter Adrian Wray
WALTON, Robert Alfred
WARD, Kenneth
WARDILL, David Henry
WATTS, Bryan Jeffrey
WHITEHEAD, Donald Gill
WHITLEY, David Anthony
WILL, Peter Milne
WILMAN, Hugh

TRANSFERS

Student to Graduate

AGNEW, Alexander Cameron
ALLAN, Dennis Joseph
ARMSTRONG, Michael John
ASHLEY, Sidney Lewis
AUSTIN, Christopher John
BAUST, Norman Charles
BECKER, Maxwell Peter
BLOOMFIELD, John
BODDINGTON, Robin Michael
BOLTON, Michael John Adams
BOWMAN, Allan George
CARRINGTON, Leslie
CHALMERS, Brian John, B.SC.(ENG.)
CHINASING, Sean Christopher
CLOUTING, Barry Trevor
COX, Capt. Donald Ward, B.SC.(ENG.), R. Signals
CRANE, Gerard
DELLER, William Bernard
DENMAN, Ronald, B.SC.(ENG.)
DICKER, Gerald Adrian, B.SC.
DOBSON, Geoffrey
DOWSETT, Michael John
DUBE, Indra Deo, B.SC.
DUDENEY, John Francis
DUTTA, Yogendra Nath, B.SC.
EDEN, Jan Lovall
ELLIOTT, Arthur
ELY, Cyril Harold Arthur
ERETT, Peter John
EVANS, Derek Anthony
FARRELL, Daniel Richard, B.SC.(ENG.)
FARTHING, David Eustace
FRERK, Lionel Clive Walter, B.SC. (ENG.)
GILBERTSON, Capt. Richard Harington B.SC.(ENG.), R. Signals
GRIMMETT, Peter
HAYDEN, Victor George
HESKETH, Peter
HUTCHINS, Peter Albert
JANES, Dennis John
JENKINS, Aium Wyn
JONES, David Lloyd
JONES, John Patrick
KITAJEWSKI, Ludomir, B.SC.(ENG.)
LARKINSON, Roger Brian, M.A.
LLEWELYN, David Thomas
LLOYD, Robert James, B.SC.
LOMAS, Kenneth Arthur
LUM, Yun Foo
LUBE, David Michael, B.SC.(ENG.)
MCINERNEY, Patrick Thomas
MAITLAND, Peter, B.SC.(ENG.)
MANNING, Frank Neville, B.SC.(ENG.)
MARGETTS, Ronald David, B.SC.
MARTIN, Garth Collingwood
MATTHEWS, John Jenkin, B.A.
MATTINGLY, Peter Henry, B.SC.
MOLUMBY, Patrick Dominic
MOODY, Frederick
MOORE, Brian Anthony
MORANT, Adrian John
MURPHY, Joseph William
PARKER, Maurice Frederick Louis, B.SC.(ENG.)
PARKIN, Alan
PEDLAR, Peter, B.SC.(ENG.)
PINEL, Alan Roy Grosvenor
PRESCOTT, William, B.SC.TECH.
PRICE, Colin Frederick
PRICKETT, Brian Rodney
RAWLINGS, Gordon William
RAYNER, Bernard Charles
ROGERS, Mark Anthony Meyrick, B.SC.(ENG.)
SAMANTA, Benoy Kumar
SAYER, Michael, B.SC.TECH.
SEN, Premasish, B.SC.
SHEPHERD, Geoffrey
SIDDON, Jack
SITTON, Robert Milo William, B.SC. (ENG.)
SIWKO, Ireneusz
SMITH, Edgar Laurence
SMITH, Joseph Peter, B.ENG.
SMITH, Owen Compton, B.SC.(ENG.)
STONE, Bernard Gregory, B.SC.(ENG.)
STUTCHBURY, Geoffrey James, B.E.
TAYLOR, John McFarlane
THRESE, Michael John
TUCKER, Howard Charles
UNDERWOOD, John Colin
VALVONA, Anthony
VICARS-HARRIS, Michael
WADDINGTON, Ernest
WALSH, Brian Sawyer, B.SC.(ENG.)
WAY, Andrew Nigel
WESSON, Noel Robert
WILKINSON, Billy
WRIGHT, Raymond, B.SC.(ENG.)
WILLIAMS, John Eric Charles Watts, B.SC.(ENG.)
YOUMANS, David Michael, B.SC.

The following elections and transfers approved by the Council are effective from the 1st March 1957.

ELECTIONS

Associate Members

ADDISON, Richard Vivian
ALEXANDER, George Edward
ANDERSON, Colin
AYRE, Maurice
BARON, Edward
BOWYER, Clifford
BRADBURY, Arthur George
BROWN, Andrew Bolam
COWCHER, Edward, B.A.
DICKS, John William
DUNMORE, Raymond Owen, B.SC.(ENG.)
FAULKNER, Edward Bazil
GAZZANA-PRIAROGGIA, Paolo, DOTT.ING.
GOODSMAN, Leslie William
GREEN, Malcolm Hobson, B.SC.
GUNN, William Frazer, B.SC.
HERD, William Richard, B.SC.(ENG.)
HIRST, Albert, B.SC.
HOON, Hari Krishen
HORSFIELD, Norman Leese
IHSAN, Mohammad, B.SC.
JEWELL, Joseph James
LYNCH, Arnold Charles, M.A., B.SC.
MART, Kenneth
MASSEY, Harold
MATHERS, John Dennis
MULLER, Ralph Willy Walter Adolf, B.SC.(ENG.)
PALANDRI, Giuseppe Luigi, DOTT.ING.
PAYNE, Ivan Salisbury, B.SC.(ENG.)
POLLARD, Donald
REES, Daniel Eirwyn, B.SC.
SALISBURY, John Harrison
SCOTT, Robert Lorne Bullard, B.SC.(ENG.)
SMEDLEY, Harry Anthony, B.SC.
SMITH, Donald Charles George, B.SC.
SMITH, Kenneth Raymond
STREET, Geoffrey
TALBOT, William Allan Dyer
THOMSON, Allister, B.SC.(ENG.)
WADDELL, William Angus, B.SC.
WALLIS, Capt. Arthur Hammond, R.N.(RET.)
WILKINSON, Cmdr. Charles Rupert Grant, R.N.
WILLIAMS, John Tennant, B.SC.(ENG.)

Companion

HEATHER, Thomas William, M.C.

Associates

BENNETT, Cyril Norman
COMBI, Anthony
DAVE, Bhailal Laxmishanker
DESBOROUGH, George Vernon
GAIGER, Eric Ernest
HUNT, Arthur William
JONES, Allan Palmer
SCOTT, Terence Leslie
STEVENS, Henry William
TUCKER, Norman Albert
VARLEY, William Eric Clifford
WILLIS, Joseph Henry

TRANSFERS

Associate Member to Member

BRAND, Norman Frederick
BRIGGS, Arthur
CAMPE, William Kenneth
COLLINS, Lucas, B.E., B.SC.
COVER, William
DAVIES, Col. John Alfred, O.B.E.
HADFIELD, Dennis, M.SC.(ENG.), PH.D.
HAMBURGER, Gerhart Lothar, Dr.Ing.
JAMES, Ivor Reginald John, B.SC.
MARSHALL, John Wilfred
MORDUCH, Major Oscar, B.SC., R.E.M.E.
OLEY, Francis William
PIPKIN, Charles Harry Broughton
POOLEY, Eric Hunns
POTTS, Norman Dean Kennedy, B.SC.(ENG.)
RICHARDSON, John Gregory

Associate to Associate Member

BETTS, Frank
HALL, Ronald Robert
HAYWARD, Richard Walter
WHITAKER, Capt. Geoffrey Charles Francis, R.N.

Graduate to Associate Member

BACH, Charles Ellis
BLYTHE, Maurice
BOON, Harold Victor
BOOTY, Martyn
BROMHEAD, James Robert
BURRELL, Henry George Iver
CANNON, Richard Walter
CARRINGTON, Hugh Malcolm
CHEETHAM, Reginald James
CHEW, Kam Pok
CROOKS, Stephen John, B.SC.
CUMBERLAND, Raymond Stuart
DAVIES, Edward Rendel, B.SC.
DIBB, Kenneth George
DUNBAR, Colin Robert, B.SC.
ELLIS, Eric James, B.ENG.
FAWELL, John Kirtley, B.SC.
FISCHBACHER, Ronald Ernest, B.SC.
FRAZIER, Arthur Alan
GELSHEN, Joseph Vincent
GERRARD, John Stephenson
GRACE, Raymond Alexander
GUNN, Samuel George William Peter
HALL, Leslie Cannon
HARDACRE, Brian Aldis, B.SC.(ENG.)
HARVEY, Frank
HILL, Kenneth Jeffery
HOGG, Arthur Leigh
HURFORD, Norman Sydney
JONES, Eric Arthur
JONES, Lionel Henry
KNIGHT, Ronald George, B.SC.(ENG.
LAFLIN, Reginald Ernest
LITTLE, Frank William
LOVE, Leonard Fernley
MAKIN, Lt. Gurbachan Singh, B.SC., I.N.
MANGNALL, Derek
MIDGLEY, Bernard Alston Wade, B.SC.
PAWSON, Derek Allan, B.SC.(ENG.)
PEARCE, John Ralph, B.SC.
PHILLIPS, William George
PIETKIEWICZ, Karol
PRESCOTT, Charles, B.SC.
RICHARDSON, John Lincoln
RIDOUT, William Harry, B.SC.(ENG.)
ROBERTS, Edward Archibald, B.SC.
SANDIFORD, Peter Vernon
SCOWEN, George Victor
SHANKLAND, James Patterson
SHAW, John Crossley, B.SC.

Graduate to Associate Member (contd.)

SOURBUT, John Alan
STACE, Francis Nigel, B.E.
SUTTON, Maurice George
TAYLOR, Kenneth James
TOLCHER, Walter James Frederick
WATKINS, James Raymond
WEST, John Godfrey Wilson, B.SC.
WESTBROOK, Michael Hereward, B.SC.(ENG.)

The following elections and transfers approved by the Council are effective from the 7th March 1957.

ELECTIONS

Graduates

BAKER, Alec Gerard James
BANKS, Jack Richard
BARGH, Brian
BARKER, Frederick Henry
BAUGHEN, John Edwin
BOWKER, Sydney
BREARLEY, Jack
BREWER, George Lester
BROWN, Alban
BULMER, Michael Stanley
BUSBY, Eric Harold
CHESSER, John
CLARKE, Norman Anthony
COOPER, John Maurice
DAVIES, Peter John
DAWSON, Keith, B.SC.
DEE, Geoffrey John
DODD, Edward Stanley
DOE, Leslie Harry, B.SC.
EASTERBY, Ronald Scott, B.E.
FERGUSON, Alastair Stephen
FISHER, Brian
FITZGERALD, Michael Antonius, B.E.
FLETCHER, Howard
FORD, Derek Rodney George
GRANGER, Cyril
GRAY-THOMPSON, Stuart
GRIFFITHS, Deryck Edwin
GRIGGS, William Ernest Nathanial
HADLEY, Bernard
HAGYARD, Raymond
HALES, Sidney George
HAMDANI, Farrukh Ali, B.SC.(ENG.), D.SC.
HARCOMBE, Iestyn
HARGREAVES, William James
HARMER, Keith Alan
HAYES, John Joseph
HEATH, Cyril Edward, B.SC.
HICKMOTT, William Frederick, B.SC.
HILL, John Terence
HOPKINS, Donald
HOSKING, Kenneth James Popplestone
HOWIE, Ian Logan, B.SC.
IBBOTT, Richard Maxwell
JOYCE, Patrick John
KAPOOR, Suresh Chandra, B.SC.(ENG.)
LAMING, Eric
LEWIS, Kenneth Charles
LIGHT, Anthony
LONG, Roger Herbert George, B.A.
LOW, Robert
LYE, Frank Charles
MCMINN, David
MADILL, William Leetch, B.SC.
MARSH, Leonard John
MARSHALL, John
MARTIN, Gerald, B.SC.(ENG.)
MASSEY, James
MAXWELL, Robert
MAYWOOD, John
MEREDITH, Lawrence Arthur
MEYERHOFF, Henry Julius, B.SC.
MILLIGAN, Miss Veronica Jean Kathleen, B.A.
MOORE, Brian William, B.SC.
MORIARTY, John James, B.E.
MOSLAND, Ole-Petter, B.SC.
OWENS, John Benjamin, B.ENG.
PATEL, Ranchhodbhai Rambhai, B.SC., M.SC.
PENNY, Michael Fred
PINCHES, Arthur Keith
POLLARD, Martin Edward
POOLE, Lionel William Graham
POWLING, Derek Clifford
PRITCHARD, John Stuart
REECE, Douglas Clague
RIDGWAY, James
ST. LEGER, Peter Merrill
SADLER, Keith
SAGGERSON, John Kenneth, B.ENG.
SAIN, Inder
SAMANT, Govind Mahadeorao
SANKEY, Gordon
SAUNDERS, John Giffen, B.SC.(ENG.)
SCOTT, Peter Gilman, B.A.SC.
SEMMENS, John
SEVENCO, Alexander Jura
SEYMOUR, Keith Charles
SHAH, Shaukat Ali
SHEPHERD, Ernest Derek
SIMPSON, Harold
STICKLAND, Geoffrey Laurence, B.A.
STUBBS, Alan
TAYLOR, Herbert Geoffrey
TRAINOR, Noel
UNSWORTH, John Joseph
WAIN, Ivan
WALKER, Ernest
WEARN, Capt. Ronald Victor, R.E.M.E.
WILLIAMS, Albert William, B.ENG.
WILLIAMS, Maurice
WILSON, Eric, M.ENG.
WINTLE, Albert John
WRIGHT, Reginald Thomas

Students

ALLIN, George
ALVANIS, Elpidoforos Nicholas
ANDERSON, Robin Clive
ANGELIDES, Odysseas Christodoulou
APPLETON, Ronald Eaton
ASHA, John Bryan
ASHTON, Maurice
ASLING, John
BAND, Ian Thomson
BARNES, Michael John
BENDALL, Reginald Mervyn
BENDING, Brian Thomas
BONAR, Frank Roberts
BOND, Robert Holmes
BORKETT, John
BOUCHER, Franklin Christopher
BOXALL, Kenneth Percival
BRIGGS, David William
BRIGGS, Kenneth Leonard
BROWN, Brian Kenneth
BROWN, Norman John
CARTER, Archer Henry
CARTWRIGHT, John Stanley
CHAUDHURI, Amitava
CHESHIRE, Arthur Derek
CLARKE, George Edmund
CLIFFORD, John Henry
CLINCH, Donald William Lister
COX, Graham Russell
CROOCK, Bennie
CUDDEFORD, Robin Clive
DAGLISH, James Hilary
DATTA, Kartik Chandra, B.SC., B.E.
DAVIES, David William
DAWSON, John
DEBENHAM, Michael John
DURANT, Alan John
ELLAM, Jack
EVANS, Brian Edward
EVANS, Byron John
FIELD, Leopold McDonald
FRANKLIN, Christopher Gavin

Students (contd.)

FREEMAN, Ernest Michael
GERRETT, Derek Charles
GIBBONS, Anthony Kingston
GNANALINGAM, Sivagurunathar, B.SC.(ENG.)
GRAZEBROOK, Robert Francis Needs
GUPTA, Harish Chander
HANKS, Leonard Edward
HANSON, Edward
HARFORD, Roger Stuart
HARMAN, David Ashley
HAWKEN, Robert Ernest
HENDERSON, Ronald Emslie
HENNAN, Errol Hamilton
HICKS, Graham John Guy
HILL, John Patterson
HILL, Samuel
HINKS, Brian Edward Maitland
HITCHCOX, Michael Edward
HOBBS, Alan James
HOLDBROOK, Leslie William, B.SC.
HOLIAN, Peter
HOLMES, John Ridsdale
HUBER, John Frederick
HUGHES, John Robert
HULSCHER, Frank Rudolf
HUMPHREYS, Dennis Arthur
HUNG, Henry Hin-Lai
HUNT, Roland Walter Benjamin
IRELAND, Ralph Edgar
JAMES, Brian Armstrong
JEFFERSON, Edgar William Wilson
KADIR, Shamsuddin Bin Abdul
KAO, Kuen Charles
KAYE, Alan Roger
KING, Ian
LEAMAN, William Mark
LEE, Edward John
LEWIS, Colin David
LIGHT, Edward George
LINGARD, John
LOMAS, Thomas
LUSKOW, Alfred Allan, B.SC.
MCCREA, Robert Eoin
MACKENZIE, Michael George
MARLOW, John Albert
MATTHEWS, John Arthur
MEADOWS, Anthony John Charles
MICHAEL, Barry Danby
MILLS, Gordon Thomas
MOORE, John
MORGAN, Brian Eric
MORTLOCK, Roy Donald
MUKERJEE, Ranjit Raj, M.SC.
NAIK, Balvant Vasanji
PARKER, Bernard Sydney
PARKER, George David
PEARSON, Rodney
PITMAN, Richard John Griffith
PUDDEFOOT, Dennis John
QUILLIAM, Barrie
RABY, George Keith
REYNOLDS, John William Lucas
RICHMAN, Maxwell Marks
ROBERTS, Ieuan Lloyd
ROGERS, Kenneth George
ROWLEY, Gordon Francis
SEEVARATNAM, Robert Jayanandan
SHERRIFF, David Harry
SHIELDS, James John
SHORLEY, Gordon Thomas
SHORT, Robert John
SMITH, Christopher
SPEIGHT, Dennis Robert
STAINER, Frank William
STENNING, Peter Ralph
TANG, Yaw Loy
TICKLE, Graham
TRIEU-NHIEN, Phu
UPPOLD, Donald Raymond
VIVEKANANDA Rao, Mallampalli
WARD, Raymond James Sydney
WELLS, Peter Neil Temple
WELSH, Joseph
WHEELER, Colin Raymond
WHITLOCK, Michael David
WILLIAMS, Kevan
WILLIAMS, Roger
WINSHIP, Colin
WOOLLONS, David John
WYLDE, Brian James
YOULD, Anthony

TRANSFERS

Student to Graduate

ALLAT, James Peter, B.A.
ALLEN, Kenneth Albert William
ANDREWS, Peter John, B.SC.(ENG.)
ARROWSMITH, Leonard Malcolm, B.SC.
ASTON, William Edward
BOWMER, Geoffrey Malcolm Ronald
BROCKWAY, Kenneth Edmund
BUDDLE, Kenneth Brunswick
CASS, Eric John
CATCHPOOLE, Lt. (L) William Edward, B.E., R.A.N.
COOK, Harold Benjamin
COOPER, Norman, B.SC.
COOPER-READE, Michael Anthony Berridge, B.SC.(ENG.)
CULLIMORE, Geoffrey Richard
DAWSON, John
DEODHAR, Madhava Dhundiraj, B.SC.
DEVLIN, James, B.SC.
DUNCAN, Norman James, B.SC.
DUNCAN, Peter
FINN, Gordon George David
FORRYAN, Lawrence Richard, B.SC.(ENG.)
FOWKE, Allan Frank
GHOSHAL, Brindabon Behari, M.SC., M.SC.TECH.
GREAVES, Peter James, B.SC.(ENG.)
GREGORY, John Brian, B.SC.
HARRIS, David Crerar, B.SC.(ENG.)
HILL, Donald Mitchell
HILL, Peter Charles John, B.SC.
HOLLINGWORTH, Edgar
HOLLOWAY, Brian Leonard William
HOTCHKISS, Derek Arthur, B.SC.
JARVIS, Peter
KALISPERAS, Malcolm
LLOYD, Lewis John, B.ENG.
MCBEAN, Donald John, B.E.
MCCOLL, Robert Donaldson, B.SC.
NUTTALL, Colin Philip, B.SC.TECH.
NUTTALL, Peter Frederick, B.SC.
PAPADOYANNIS, Michael, B.SC.
PARKER, Douglas Albert
PETRIE, Colin Louden
PRIVETT, Ian Donald, B.SC.(ENG.)
RAJAN, Doraiswamy Ananda
ROSE, Michael John, B.SC.(ENG.)
RUSSELL, Peter Frederick
SAGUES, Jean Isaac, B.SC.(ENG.)
SANDFORD, Pilot-Officer Bryan Moile, B.SC., R.A.F.
SCOTT, Frank Victor, B.A.
SEYMOUR, Derek
SINHA, Jayanti Kumar, M.SC.
SMALLWOOD, Brian Michael
SMEDLEY, Clifford Frederick
TAYLOR, John Richard
THOMAS, Iorwerth, B.SC., PH.D.
VOADEN, John Herbert
WALMSLEY, Bruno Joseph, B.SC.
WALWYN, Timothy Christopher Lingard, B.A.
WANKLING, James Leonard, B.SC.(ENG.)
WARD, Christopher John
WARDLE, James
WARE, Alan Henry
WHITE, John Kennedy Rose
WHITE, Kenneth Edward
WILSON, John Greer, B.SC.
WINN, John David William, B.SC.(ENG.)
WINYARD, Terence
WISTOW, Eric
WITHAMS, Kenia Frederick Leonard
WOOD, Michael Richard
WRAY, Robert William, B.SC.
WRIGHT, Albert William

THE ENGINEERING INSTITUTIONS' EXAMINATION (PART I) OCTOBER 1956

There are six Institutions participating in the Engineering Institutions' Examination for Part I:

THE INSTITUTION OF CIVIL ENGINEERS
THE INSTITUTION OF MECHANICAL ENGINEERS
THE INSTITUTION OF ELECTRICAL ENGINEERS
THE INSTITUTION OF MUNICIPAL ENGINEERS
THE INSTITUTE OF MARINE ENGINEERS
THE INSTITUTION OF GAS ENGINEERS

The following candidates satisfied the examiners in the compulsory technical subjects of Part I (Mathematics, Applied Mechanics, Heat Light and Sound, Principles of Electricity):

BRITISH ISLES

APEDAILE, William Walker[2]
ATKINSON, Mervyn James[2]
BADRINATH, Erode Ramaswami[1]
BAKER, Alan George[2]
BARVE, Sharad Purushottam
BEASANT, Robert Henry[2]
BERRY, William Stewart[2]
BLAKENEY, Noel Peter
BODEN, Peter Stuart[2]
BOUGH, Reginald Peter[2]
BRENNAN, Francis Michael
BRIGHTMORE, Jesse Vernon[2]
CAPEL, Derrick[2]
CLARKE, Michael Rushton[2]
COLLETT, Ronald George[2]
COLLINS, Raymond Patrick[2]
COOKE, John Christopher[2]
CORNTHWAITE, Arthur Geoffrey[2]
DAVIES, John Arnold[2]
DAVIES, John Edmund[2]
DE LORD, Bernard Pereira[2]
DEMPSEY, Thomas Anthony
DOWNES, John Thomas
DUFFELL, James Roger[2]
DYCHER, Thomas Edward
ECCLESTON, William Henry
EDWARDS, Brinley John
EDWARDS-WINSER, Brian[2]
ELLIS, David Brian[2]
ENDEAN, Peter Walwin
ERBY, John[2]
ESCOTT, Thomas Oswald
FARRAR, David William
FELLOWS, Ronald[2]
FOSTER, Kenneth Denning[2]
GEAKE, Richard Nicholas Edward[2]
GIBBS, Garry Keith
GOUDGE, Alan Edward[2]
GRAINGER, John Joseph Anthony[1]
GRIFFITHS, David Raymond[2]
HAIGH, Neville James[2]
HALL, Ronald[2]
HALL, Ronald Robert
HALLWORTH, Robert Philip
HARVEY, Robert David Stanley
HATT, Michael John
HAYWARD, Richard Walter
HEARSEY, Geoffrey Richard
HEATH, Donald Frederick[2]
HITCHING, Wilfrid Wallace[2]
HOLDSWORTH, John Edward[2]
HUNTER, John Rubley[2]
JACKSON, Raymond Arthur[1]
JONES, Morris William[2]
JORDAN, Alan George[2]
KEARSEY, John Richard Morgan[2]
KHAN, Mohamed Sideek[2]
KILNER, Stephen Roy[2]
KNIGHT, David Raymond[2]
LARKIN, Paul Fergus
LAZENBY, David William
LEAN, John Leonard
LEISHMAN, Stanley Henry Michael[2]
LETMAN, John Albert[2]
MCAULIFFE, Arthur Gartside
MCCOLGAN, Anthony Eunan
MACGEORGE, Archie[2]
MCMILLAN, William Anthony[2]
MAHER, John Joseph[1]
MALYON, Robert Bryan Howard
MANN, Geoffrey Edward[2]
MARTLEW, Allan
MAY, Ronald
MILLEA, Trevor Graham[2]
MIRZA, Mohammad Akbar
MORAGHAN, James Sylvester
MUNONYEDI, Onwughalu
NASSIM, Victor Haskell[2]
NEWMARK, David Cope[2]
NICHOLAS, Wilfred Arasaratnam[2]
NOORANI, Abbas Taiyabali[1]
O'CONNOR, Edward James[1]
O'DWYER, Edward Francis[2]
OLDFIELD, Peter John[2]
PATEL, Jayant[2]
PENN, Richard David[2]
PERERA, Willorarachige Srianandа Dharma Bandu[2]
POTTER, Christopher Alan[2]
PRIMROSE, David James[2]
PRIOR, Michael Arthur
RAMSBOTTOM, James[2]
READ, Colin[2]
RICHARDSON, Alan
ROBINSON, Richard Albert[2]
ROCHESTER, Terence Anthony[2]
ROWLANDS, Michael Keith[2]
ROWLEY, Geoffrey Charles
ROY, Mylamood Marthanan Kumaran[2]
ROY, Rathindra Nath[1]
SCHALLER, Brian George Allen[2]
SCOTT, Peter John[2]
SIMKINS, Robert Arthur James[2]
SLADDIN, John Peter[2]
SMALLEY, Lawrence Stone[2]
SMITH, Ian Warburton[2]
STEPHENSON, Frederick William[2]
STEVENSON, John Trevor
STOWER, Timothy[2]
SUGDEN, Alan[2]
TAYLOR, David
TEMPERLEY, Eric Malcolm[2]
TIMMINGTON, Geoffrey Wilfred[2]
TWIGG, David Joseph[2]
WALFORD, Geoffrey Morris
WALKER, Allan[2]
WATLING, Derek Wayne[2]
WATSON, William John[2]
WATT, Alan Vallack
WILSON, Andrew John[2]
WILSON, Paul Edward[2]
WOOD, Martin Hemsley[2]
YEATES, Patrick Joseph Laurence
ZAKI, Mohamed[1]

OVERSEA

CLARE, Jackson Abadee[2]
COLEMAN, Richard Derek[2]
DUNNE, Melvin Robert[2]
GLAISTER, Barry Michael Murray[2]
HADDON, Raymond Arthur William[2]
HARRADINE, John Michael[2]
HEALY, Peter James[2]
JUST, Jack Tama Haigh[2]
LAWN, Geoffrey David
RAGHOOBAR, Ingarman
SCHON, Paul William
SEARCHFIELD, Gary Thomas[2]
SHAH, Dhirajlal Bechardas[1]
SMITH, Ivan Ronald
SUTTON, Allan Fauconnier[2]
TREUREN, Gustaaf Hendrik George
VELTMAN, Frederik[1]
VERWAARD, Jan Marinus[2]

[1] *Also satisfied the examiners in the subject of English.* [2] *Also satisfied the examiners in the subject of Theory of Structures.*

The following candidates have been permitted to enter the Examination under special circumstances and have satisfied the examiners in the subjects indicated:

BRITISH ISLES

ARMSTRONG, Malcolm Sneddon[4]
BENNETT, John Charles[4]
BODDINGTON, Robin Michael[1]
BOWMAN, Thomas John[3]
BROWN, Albert[3]
CARRUTH, Eric[3]
CHRIMES, Robert Arthur[3]
EGWUATU, Gordon Chukwuka[3] [4]
FARROW, Arthur Leslie[4]
HEANEY, Robert John[4]
HODGE, Russel James[3] [4]
KENWORTHY, Ernest Wild[2]
LYE, Frank Charles[4]
NORRIS, George James[4]
OSBORNE, Bertram Roland[3] [4]
PARKER, Donald John[4]
RICHARDSON, Colin[3]
ROBERTSON, Duncan McRae[3]
SMITH, Stephen Fauré[4]
SOLLY, John McCafferty[3]
WEIGHTMAN, Brian[4]
WILSON, Gilbert[4]

OVERSEA

BENTON, Stanley Joseph[4]
WOODWARD, Colin Francis[4]

[1] *Mathematics.* [2] *Applied Mechanics.* [3] *Heat, Light and Sound.* [4] *Principles of Electricity.*

The following candidates have satisfied the examiners in the subject of English:

BRITISH ISLES

AYRE, Maurice
BETTS, Frank
BRADBURY, Arthur George
BURGESS, John Norman
CHILD, Cecil
CHRIMES, Robert Arthur
DEE, Geoffrey John
DUNMAN, John Percival George
FORREST, Sidney Arthur Edward
HORSFIELD, Norman Leese
LEWIS, Edward Edwin
NICHOLS, Geoffrey Mills
PAIS, Joseph Cyril
RAJADHYAKSHA, Diwaker Anant
SMITH, Kenneth Boyd
WINNARD, Neville Rex

OVERSEA

SMITH, Raymond Graham
TZAMBIRAS, John

THE INSTITUTION EXAMINATION *(contd.)*

THE INSTITUTION EXAMINATION (PARTS II AND III) OCTOBER 1956

PART II

BRITISH ISLES

CHAKRABORTY, Jatindra Mohon
FINLAY-MAXWELL, David Campbell
SENIOR, Graham
WURR, John Cecil[1]

OVERSEA

BAILEY, William Dalziel
BULL, William Harold
CLENDINNING, Barry Arthur[2]
EDDY, David Charles Ancell[1]
LEE, Thomas Joe
PARNELL, James Crawford
SMITH, Colin Morice[1 4]

PART III

BRITISH ISLES

LLOYD, Robert James[3]
PRINS, Aurele Gerald Edward[3]
SEN, Premasish
TALBOT, William Allan Dyer[5]

OVERSEA

BECKER, Maxwell Peter
FAULKNER, Edward Bazil[3]
MARTIN, Garth Collingwood

[1] *Examined in Electrical Engineering I only.* [2] *Examined in Thermodynamics only.* [3] *Passed in Advanced Electrical Engineering.* [4] *Examined in Mathematics only.* [5] *Passed in two Special Subjects.*

Contents of the Current Issues of the *Proceedings*

DATE OF JOURNAL REVIEW OR SPECIAL ARTICLE

PART A. POWER ENGINEERING (APRIL 1957)

E. R. LAITHWAITE, M.SC., AND P. J. LAWRENSON, B.SC.
February 1957 — **A Self-Oscillating Induction Motor for Shuttle Propulsion** (PAPER NO. 1988 U, FEBRUARY 1956)

PROFESSOR F. C. WILLIAMS, O.B.E., D.SC., D.PHIL., F.R.S., E. R. LAITHWAITE, M.SC., AND L. S. PIGGOTT, M.SC.
February 1957 — **Brushless Variable-Speed Induction Motors** (PAPER NO. 2097 U, JUNE 1956)

P. R. HOWARD, PH.D., B.SC.(ENG.)
April 1957 — **Insulation Properties of Compressed Electronegative Gases** (PAPER NO. 2128 M, AUGUST 1956)

P. R. HOWARD, PH.D., B.SC.(ENG.)
April 1957 — **Processes Contributing to the Breakdown of Electronegative Gases in Uniform and Non-Uniform Electric Fields** (PAPER NO. 2260 M, APRIL 1957)

COLIN ADAMSON, M.SC.(ENG.), L. BARNES, M.SC.TECH., AND B. D. NELLIST, M.SC.TECH.
April 1957 — **The Automatic Solution of Power-System Swing-Curve Equations** (PAPER NO. 2035 S, MAY 1956)

A. S. ALDRED, M.SC., AND P. A. DOYLE, B.E.
March 1957 — **Electronic-Analogue-Computer Study of Synchronous-Machine Transient Stability** (PAPER NO. 2015 S, JUNE 1956)

R. DELL
April 1957 — **The Application of Electricity to Railway Signalling** (*A Review of Progress*) (PAPER NO. 2301)

J. STRINGER, M.A., AND A. T. WILFORD, B.SC.
April 1957 — **The Application of Electricity to Signalling for Road Transport** (*A Review of Progress*) (PAPER NO. 2346)

E. G. HOPKINS, PH.D., B.E.
April 1957 — **A Thermionic Rheostat for Automatic Control** (PAPER NO. 2288 M)

A. T. CHADWICK
North Staffordshire Sub-Centre: Chairman's Address

D. I. LAWSON, M.SC., AND J. F. FRY, B.SC.
April 1957 — **Fires of Electrical Origin** (PAPER NO. 2316 U)

Written discussion on **An Asymmetrical Induction Motor Winding for 6 : 3 : 2 : 1 Speed Ratios**

Written discussion on **An Electronic Over-Current Relay for Electrical Machines**

PART B. RADIO AND ELECTRONIC ENGINEERING (MARCH 1957)

See *Journal*, March 1957, page 186.

PART B. SUPPLEMENT No. 4

See announcement headed 'The First Transatlantic Telephone Cable' on p. 246.

PART C. MONOGRAPHS (MARCH 1957)

See *Journal*, March 1957, page 187.

Forthcoming Events at Savoy Place

All meetings are held at Savoy Place, beginning at 5.30 p.m. (tea at 5 p.m.), except where otherwise stated. The nature of the meeting is indicated by the following key:

E EDUCATION DISCUSSION CIRCLE
I INFORMAL
M MEASUREMENT AND CONTROL SECTION
O ORDINARY
R RADIO AND TELECOMMUNICATION SECTION
S SUPPLY SECTION
U UTILIZATION SECTION

After each paper that has now been published is added the month that a synopsis has appeared in the *Journal* under 'Monographs and Papers published individually this month', i.e. about the time the paper has been published as a separate. A paper that has not yet been published will be available at least ten days before the meeting at which it will be read.

April 1957

M **16** *Tuesday* M. WATERS, B.SC., A. J. KING, D.SC., M.SC.TECH., *and* M. KAUFMANN will open a discussion on 'The Measurement of Currents in High-Voltage Circuits without Orthodox Current Transformers'†

S **24** *Wednesday* S. S. ROKOTYAN Lecture on 'Transmission of Electrical Power at 400 kV in the Soviet Union' (To be presented in English by B. P. LEBEDEV)

O **25** *Thursday* T. INGLEDOW, D.SC., R. M. FAIRFIELD, B.SC.(ENG.), E. L. DAVEY, B.SC.(ENG.), K. S. BRAZIER, B.SC.(ENG.), *and* J. N. GIBSON '138 kV Submarine Power Cable Interconnection between the Mainland of British Columbia and Vancouver Island' (Paper No. 2354 S) *Synopsis:* See p. 229

R **29** *Monday* Informal Evening on 'Radio in Air-Sea Rescue'. Talks by G. W. HOSIE, D. KERR *and* W. KIRYLUK†

May 1957

E **6** *Monday* C. GRAD *and* A. DRAPER, B.SC.(ENG.) will open a discussion on 'The Co-ordination of Education and Practical Training in Sandwich Courses'* (At 6 p.m., tea at 5.30 p.m.)

M **7** *Tuesday* F. W. MEREDITH, B.A. Lecture on 'Invention and Nature'‡

U **9** *Thursday* H. J. MILLER Lecture on 'The World's Copper Resources'‡

R **15** *Wednesday* A. G. MILNES, D.SC. 'Transistor Circuits and Applications.'

R **18** *Saturday* Repeat Radio and Telecommunication Section Visit to B.B.C. and I.T.A. Television Transmitting Stations

20 *Monday* Discussion on the Report on the Development of Hydro-Electric Power in the Soviet Union. (Joint meeting with The Institutions of Civil and of Mechanical Engineers at The Institution of Civil Engineers, Great George Street, Westminster, S.W.1; copies of the Report are available from the Secretary of The Institution of Electrical Engineers)

S **22** *Wednesday* J. M. MAGOWAN 'Voltage Performance of Series Capacitors in Transmission and Distribution Lines' (Paper No. 2252 S) *Synopsis:* December 1956 (To be read by L. L. LANGTON)

23 *Thursday* ANNUAL GENERAL MEETING *followed by* A. D. BOOTH, D.SC., PH.D. Lecture on 'General Applications of Digital Computers'‡ (At approximately 6.30 p.m.)

S **25** Supply Section Visit to Oxford

U **31**–**June 2** *Friday–Sunday* Utilization Section Visit to Stratford on Avon

June 1957

M **14** *Friday* Measurement and Control Section Visit to Leicester

E **28** *Friday* Exhibition of Apparatus for Teaching Electrical Engineering (At Northampton Polytechnic, St. John Street, E.C.1, 6–8.30 p.m.)

July 1957

1–5 *Monday–Friday* Summer Meeting in the North-Western Centre

September 1957

S **5–9** *Thursday–Monday* Supply Section Visit to Belgium

R **18–22** *Wednesday–Sunday* Radio and Telecommunication Section Visit to the Netherlands

* No advance information will be available and no Press report will be permitted.
† An abstract of the introduction will be available in advance.
‡ No advance information will be available.

British Nuclear Energy Conference: Forthcoming Programme

MAY 1 *Wednesday*

A half-day discussion on the Metallurgy of Niobium, sponsored by The Institute of Metals, will be held at Church House, Westminster, at 10 a.m. The following papers will be presented and discussed:

THE DEVELOPMENT OF NIOBIUM A. B. McIntosh

THE PURIFICATION OF NIOBIUM BY SINTERING W. G. O'Driscoll and G. L. Miller

THE PRODUCTION AND FABRICATION OF MASSIVE NIOBIUM METAL L. R. Williams

THE PHYSICAL AND MECHANICAL PROPERTIES OF NIOBIUM C. R. Tottle.

THE MELTING POINT OF NIOBIUM T. H. Schofield.

All these papers will be printed before the 1st May in the *Journal of The Institute of Metals.*

OFFICERS OF THE INSTITUTION

PATRON: H.M. THE QUEEN

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Hon. Secretary: A. A. BECKINGSALE, Central Electricity House, 26 Oakfield Road, Bristol, 8.

Western Utilization Group

Chairman: E. R. RADWAY.

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Hon. Secretary: R. WRIGHT, M.B.E., 4 Buckingham Gardens, Madras, 12.

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FAR EAST

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Chairman: R. J. WEIR, B.ENG.
Hon. Secretary: J. A. SMITH, 15 Zetland Road, Stockton-on-Tees.

ANNOUNCEMENTS TO MEMBERS (*contd. from p. 247*)

THE HENRY NIMMO PRIZE

Mrs. Henry Nimmo has endowed a fund in memory of her late husband to be used for the purpose of an award to students. Henry Nimmo took a prominent part in the activities of The Institution and for a number of years he held the office of Honorary Treasurer. At the time of his death in 1954 he was Chairman of the Southern Electricity Board.

To commemorate his work the Council have decided to use the fund to award an annual prize of £15 to a student of outstanding merit who obtains an Electrical Technicians' Certificate of the City and Guilds of London Institute under the Institute's new scheme of awards for electrical technicians' courses. A provisional selection of candidates will be made on the results of each intermediate examination and the prize will be awarded to the best of those selected candidates who have continued to show outstanding achievement in the third and fourth years of the course. A successful candidate will also be required to satisfy the Council that he has pursued an acceptable programme of technician training in industry.

The Council hope that in the course of time the Henry Nimmo Prize for electrical technicians' courses will earn an esteem comparable with that enjoyed by the Page Prize for students following National Certificate Courses in Electrical Engineering.

ADDRESS BY PROFESSOR RAWCLIFFE

Professor G. H. Rawcliffe has available some duplicated copies of the complete text of his Chairman's Address to the Western Centre, a shortened version of which appeared in the February *Journal*; he will be glad to send one of these to any member who would care to have one. His address is University Engineering Laboratories, University Walk, Bristol 8.

ANNOUNCEMENTS TO MEMBERS

THE HOMES FUND

SUMMARY OF CONTRIBUTIONS RECEIVED TO 25TH MARCH 1957

	No. of Contributors	£	s.	d.
£1 000 and over	6	6000	0	0
£100 to < £1 000	30	6586	3	0
£5 to < £100	819	8754	3	3
£2 to < £5	1966	5362	12	2
Under £2	21483	11137	12	8
		£37840	11	1

HONOURS AND DISTINCTIONS

The name of the following member of The Institution was included in the New Year Honours and Distinctions conferred by Her Majesty, but was inadvertently omitted from the list published in the February *Journal*:

OFFICER OF THE ORDER OF THE BRITISH EMPIRE

Hitch, Lt.-Col. F. A. N., R.A. (*Associate Member*).

NOMINATIONS

BRITISH STANDARDS INSTITUTION ENGINEERING DIVISIONAL COUNCIL AND TECHNICAL COMMITTEE

Engineering Divisional Council

The Council have nominated Sir John Hacking, PAST-PRESIDENT, to serve on the above Council in place of Col. B. H. Leeson, C.B.E., T.D., PAST-PRESIDENT.

Committee on Electrical Switch and Control Gear (*ELE*/10)

The Council have nominated Mr. J. A. Broughall, B.SC.(ENG.), MEMBER, to serve as their representative on the above Committee.

HEADS IN THE SAND (*continued from p. 195*)

graduate ready to undertake professional work. This difference may be more apparent than real, but, nevertheless, it draws attention to the risk of overlapping in the work done in science subjects in school and in university —an overlapping with a difference in approach which leads in many places to re-teaching.

The high proportion of women students, the important status of the teaching profession and other features of the Report have received much comment in the Press and elsewhere. It is not suggested that they are of minor importance; on the contrary, they are points worthy of serious study. In the light, however, of recent studies of many other education systems, it is undoubtedly on the years in the schools between the old matriculation standard and present-day university entrance that we must bring our guns to bear with the greatest urgency.

THE ANNUAL GENERAL MEETING

Notice is hereby given that the **Annual General Meeting of The Institution of Electrical Engineers** will be held on Thursday, 23rd May 1957 at 5.30 p.m., at the Institution Building, Savoy Place, London, W.C.2, to receive and consider the Accounts for the year ended 31st December 1956, and the Annual Report of the Council, and to elect Auditors.

Copies of the Accounts and Report (a condensed version of which will in due course be published in the *Journal*) can be obtained on application to the Secretary about ten days before the date of the meeting.

By order of the Council,
W. K. BRASHER, *Secretary*.

LECTURE BY DR. A. D. BOOTH

Members are reminded that the Annual General Meeting on the 23rd May will be followed at 6.30 p.m. by a lecture on 'General Applications of Digital Computers' by A. D. Booth, D.SC., PH.D. Dr. Booth is Head of the Computation Laboratory at Birkbeck College, University of London.

DISCUSSIONS AT MEETINGS

The Council desire it to be understood that contributions to the discussions at meetings should not be read from manuscript, since they consider that this form of presentation is contrary to the true spirit of a discussion.

WRITTEN CONTRIBUTIONS TO DISCUSSIONS

Members who are unable to be present at a meeting, or who, if present, do not have an opportunity of speaking, may submit written contributions to the discussion which will be considered for publication in the *Proceedings*. This does not apply to Informal Meetings or Discussion Meetings.

Members are reminded that written contributions on papers published in the *Proceedings* without being read at meetings will be considered for publication.

Members should note that the Papers Committee have been obliged to set a limit of 300 words for contributions of either sort.

THE INSTITUTION EXAMINATION

A new issue of the Examination Regulations, dated January 1957, contains only minor changes from the previous edition, dated March 1956. The main points are:

(i) Preliminary notice that the Engineering Institutions Standing Committee for Part I will not conduct an examination in English after 1960. After this date all candidates who wish to satisfy The Institution's educational requirements must offer an approved alternative qualification in the subject of English Language.

(ii) The entry fee for the Part I examination will be raised to £5 (£1 5s. per single paper) with effect from October 1957.

(iii) The syllabuses for Heat, Light and Sound, and for English have been modified.

THE FIRST TRANSATLANTIC TELEPHONE CABLE

A SUPPLEMENT TO THE *PROCEEDINGS*

Part B, Supplement No. 4, of the *Proceedings* is now ready. As previously announced, this contains the Symposium of Papers on the Transatlantic Telephone Cable, presented on the 24th January 1957 at the Joint Meeting with the American Institute of Electrical Engineers and the Engineering Institute of Canada, linked by the cable.

This Supplement, with its contents and index pages—and in a semi-stiff cover—is complete in a single issue. The edition is limited, so that those who have not already secured their copies are advised to apply for them without delay. The prices (post free) are 10s. to members and 17s. to non-members.

BRITISH INSTITUTE OF MANAGEMENT

SUMMER SCHOOL IN PRODUCTION MANAGEMENT

This year the British Institute of Management opens the first of a series of specialist management summer schools. A summer school in Production Management will be held from Sunday 14th July until Saturday 20th July, this year, at Crewe Hall, Sheffield University. The course is being planned by a committee on which the Institutions of Mechanical, Electrical and Production Engineers, and the Institution of Works Managers, are represented.

The school will be limited to a maximum of 50 people preferably between the ages of 30 and 40, holding responsible positions in Production Management or Works Management. The Director of Studies will be Mr. Peter Gorb, B.A., M.B.A. (Harvard), Director and Manager of C. F. Hawes Ltd. All inquiries should be made to the British Institute of Management, Management House, 8 Hill Street, London, W.1.

JOINT MEETING OF THE THREE INSTITUTIONS

MONDAY, 20TH MAY 1957

A Joint Meeting of the Institutions of Civil, Mechanical and Electrical Engineers will be held at The Institution of Civil Engineers on the 20th May 1957, at 5.30 p.m. (see p. 241). At this meeting the Report of the British delegation which visited the U.S.S.R. from the 10th to 24th October 1956, to examine hydro-electric installations and developments there, will be presented for discussion.

The British delegation, which comprised six engineers all of whom were authorities on hydro-electric development, was appointed by the three Institutions. It was led by Sir John Hacking and other members were Mr. A. A. Fulton, Dr. S. P. Hutton, Dr. W. MacGregor, Mr. R. W. Mountain, Mr. H. West and Major R. S. W. Jarvis (*Interpreter*).

The delegation was received hospitably in Moscow by officials from the Ministry of Power Stations, and taken to the Ministry, where they were greeted by the Minister, Mr. Malenkov. The programme for the 12-day visit included tours of as many hydro-electric sites, works, and research establishments as could reasonably be compressed into the time available.

It is expected that a return visit with a similar object will be made by a team of Russian engineers. No date has been fixed but the summer of this year has been suggested.

REPORT ON ENGINEERING EDUCATION IN THE SOVIET UNION

The above Report, which was presented and discussed at a Joint Meeting of the Institutions of Civil, Mechanical and Electrical Engineers, held at The Institution of Civil Engineers on the 25th February 1957, is being printed as a pamphlet, and this will include the discussion at the meeting. The pamphlet will probably be available by the end of April; copies, price 3s. each, can now be ordered from The Institution of Electrical Engineers.

TECHNICAL STATE SCHOLARSHIPS

The Ministry of Education have announced details of the award of Technical State Scholarships in 1957 and 1958. The number of these scholarships available for award in 1957 will be 225. They will be offered to students who have gained an Ordinary National Certificate or comparable qualification for a full-time honours degree course at a university or for a course leading to the Diploma in Technology at an establishment for further education. Further particulars of these awards, including application forms, can be obtained from the principals of establishments for further education or from the Ministry of Education, F.E.1 (D), Curzon Street, London, W.1.

In 1958 new conditions of award will apply and applications will be considered only from:

(i) Candidates who have been engaged for the previous two years in *part-time* study at establishments for further education; except that students following National Diploma courses will also be eligible.

(ii) Candidates who have not proceeded beyond Ordinary National Certificate level, A.1 level in Higher National Certificate courses, or corresponding levels in other types of course.

The effect of these changes will be to exclude from the scheme in 1958 and later years two categories of students who have hitherto been eligible:

(*a*) Students who have followed full-time courses leading to the G.C.E.(A) level. In future such students will be expected to apply for ordinary State Scholarships and not for Technical State Scholarships.

(*b*) Students who have obtained Higher National Certificates. National Certificate students will need to decide at the O.N.C. stage, or at the latest the A.1 stage, whether they wish to enter for a Technical State Scholarship.

A CORRECTION TO THE FEBRUARY ISSUE

We regret that in the short review of the paper entitled 'New Instruments for Induction Motor Analysis' by B. J. Chalmers and A. R. Daniels, which was published in the February *Journal*, pp. 103–104, the two diagrams (Figs. 1 and 2) were incorrectly shown. The two circuits should be interchanged, with the captions left as printed.

SUBSCRIPTIONS AND NATIONAL SERVICE

Under a recommendation approved by the Council the subscription payable by Graduate and Student members during their term of National Service is reduced to 10s. per annum. A member wishing to take advantage of this dispensation should advise the Secretary, giving the date of his call-up.

(*Announcements to Members are continued on p. 245.*)

LONDON REPORT

JOINT MEETING OF THE THREE INSTITUTIONS

Presentation of the Kelvin Medal

A joint meeting of the Institutions of Civil, of Mechanical and of Electrical Engineers was held in our Lecture Theatre at Savoy Place on the 7th February 1957. The three Presidents, Sir Arthur Whitaker, Mr. T. A. Crowe and Sir Gordon Radley, were present. After the conclusion of some items of domestic business, Sir Gordon Radley vacated the chair in favour of Sir Arthur Whitaker, President of The Institution of Civil Engineers.

At this meeting Sir Ifor Evans delivered the Third Graham Clark Lecture, and the text of this is printed on pp. 196–201. The opportunity that the joint meeting provided was also used to present to Sir John Cockcroft the Kelvin Gold Medal that he was awarded in April 1956. This medal, first struck in 1920, is awarded triennially as a mark of distinction in engineering work or investigation of a kind with which Lord Kelvin was especially identified. The award is made by a committee consisting of the Presidents of a number of engineering and technological institutions after they have considered recommendations received from similar bodies in all parts of the world. This year it was the turn of our Institution to arrange the ceremony of the presentation, which was made to Sir John Cockcroft by Sir Arthur Whitaker, President of The Institution of Civil Engineers.

Sir Arthur Whitaker presents the Kelvin Medal to Sir John Cockcroft

Before the actual presentation Sir Gordon Radley spoke as follows in appreciation of Sir John Cockcroft's work:

> I feel that it is a very great honour to have been asked to introduce to you the Kelvin Medallist, the more so as the recipient is Sir John Cockcroft. One likes to think that the shade of Lord Kelvin, whose picture looks down on us from these walls and whose memory the Medal commemorates, continues to keep a friendly and sympathetic eye on these triennial proceedings. If this be so, then rarely can that shade have felt the occasion and the man were better matched than they are now, for Sir John Cockcroft's whole career has epitomized the fruitful marriage of science and engineering.
>
> In acknowledging recently the award of the Faraday Medal, Professor Lawrence, the distinguished American scientist and fellow worker in the atomic field, said, 'Engineers have played a vital role in nuclear physics. Indeed, Sir John Cockcroft was trained as an electrical engineer, and perhaps without this background of engineering education there would not have been the Cockcroft and Walton accelerator by which was achieved the artificial disintegration of matter.'
>
> I could not agree more. Sir John's pursuit of the problems of artificial radioactivity has been strenuous and successful, though it was interrupted on the outbreak of war, when his competence and versatility found another field of action and he became Assistant Director of Scientific Research in the Ministry of Supply, concentrating on the application of radar techniques to coast and air-defence problems.
>
> In 1944, however, he returned to the field of atomic studies, moving to Canada to take charge of the Canadian atomic energy project. He directed the Montreal and Chalk River laboratories until 1946, when he returned to England as Director of the Atomic Energy Research Establishment at Harwell, a position which we all know he has filled with outstanding distinction and still holds.
>
> It needs no words from me to emphasize the importance to the country and, indeed, to the world, of the pioneering work carried out under Sir John's direction, at Harwell, towards the application of nuclear energy for peaceful purposes. Finally, academic and experimental study of reactor design has come to fruition in the successful commissioning and operation of Calder Hall. . . .
>
> We are all aware how the growing shortage of fossil fuels is bearing on the world and how the impact of this shortage seems likely to be most acutely felt in our own country. We have every reason to be grateful that by the dedicated labours of Sir John and his many colleagues a way has been found, although at the eleventh hour, to tap a new and, by comparison, inexhaustible source of power.

The three Presidents: Mr. T. A. Crowe, Sir Arthur Whitaker, and Sir Gordon Radley

I congratulate you, Sir John, on this award. In doing so, I know that I am speaking for all of us here.

In his reply Sir John Cockcroft said:

I thank you very much for what has been said. I am extremely honoured by the award of this Medal, especially because of its association with Lord Kelvin, who did so much both for pure science and for applied science in the last century.

It is worth remembering, I think, that Lord Kelvin was very interested in this question of energy resources, particularly as it affected the age of the earth, and at times he was very pessimistic about this. He said, at one time, 'Many say that the inhabitants of this planet will not continue to enjoy the light and heat essential to their life for many years longer unless sources not at present known to us are produced in the great store-house of Creation'.

It was Rutherford who, after the discovery of radium delivered a lecture which enabled the newspapers to come out with great headlines, 'Doomsday Postponed'.

It has been said that we look like approaching another period of difficulty over energy resources. It has been a very great personal pleasure to me to work on both academic nuclear physics and then on applied nuclear physics, and to see these two come together to help to solve our future problems. Once more we may perhaps say, 'Doomsday Postponed'.

Then followed the delivery of the Graham Clark Lecture, and at its conclusion a vote of thanks to Sir Ifor Evans was proposed by Mr. T. A. Crowe and seconded by Sir Gordon Radley.

MEASUREMENT AND CONTROL SECTION

The Limits of the Oscillograph

A joint meeting with the Radio and Telecommunication Section was held on the 12th February. Dr. Denis Taylor, in the chair, welcomed Dr. J. S. McPetrie, Vice-Chairman of the Radio and Telecommunication Section, and members of that Section who were present.

The first paper, *The Ultimate Performance of the Single-Trace High-Speed Oscillograph*, by M. E. Haine and M. W. Jervis, was presented by Mr. Haine. He analysed the theoretical performance of this type of oscillograph in terms of electron-gun characteristics and the spherical aberration of practical electron lenses. This analysis led to a discussion of the limits to writing speed and deflection sensitivity, and Mr. Haine showed that a considerable improvement over the best present-day designs is theoretically possible. His results predicted, for example, that improvements of the order of 10-100 times the temporal resolution should be possible without loss of deflection sensitivity.

The second paper, *The Design and Performance of a New Experimental Single-Transient Oscillograph with Very High Writing Speed*, by the same authors, was presented by Mr. Jervis. In this, a description was given of a new design of oscillograph which attempts to give a performance very much nearer the theoretical limit of temporal resolution than has previously been attempted, and Mr. Jervis indicated how this had been achieved in the experimental design. A demountable construction was used which permitted various types of deflector systems to be employed, and the recording was by the direct action of electrons on a photographic plate. Mr. Jervis showed a number of oscillograms obtained with the new instrument. The resolution was about 2×10^{-13} sec spot width, which was in agreement with that expected theoretically.

The discussion which followed was of a high standard and was of interest to both the specialist and the non-specialist, being concerned equally with the design of these high-speed oscillographs and the practical problems of using them. Mr. D. F. Oakeshott, who opened the discussion, mentioned that it was gratifying to see not only the very penetrating theoretical analysis of the high-speed cathode-ray oscillograph, but also that these principles could be put into practice to construct an oscillograph of very high performance. Dr. R. Feinberg made a number of detailed comments on the terminology and on the design of the oscillograph, and he also discussed at length the use of phosphors in indirect photography. He thought that a phosphor screen might possibly give a much higher performance than the authors suggested.

Dr. R. F. Saxe pointed out that, up till the present time, only oscillographs with a time range of 10^{-9} sec had been available for recording. The authors had now shown that recording is possible down to a range of about 10^{-12} sec. However, there was still the difficulty of putting the transient into the oscillograph—in other words, of coupling it to the electron beam—without distortion. As was remarked by another speaker, it is one thing to put on a sine wave and another to put in a transient of unknown shape, look at the oscillogram and say, 'That is the shape the transient actually is'. Dr. Saxe pointed out that there were, in fact, other problems which would need to be solved before this new instrument could be used to the limit of its attainable performance. Mr. H. G. Riddlestone, Mr. P. A. Einstein and Capt. P. P. Eckersley also spoke in the discussion and their questions were briefly answered by the authors.

At the end of the meeting Dr. J. S. McPetrie proposed a vote of thanks to the authors and this was carried with acclamation.

D. T.

SUPPLY SECTION

Wrapped-up Copper

'A transformer makes no noise (*cheers*)—or not much. It is only brown paper and cardboard tied together with string, and with bits of soft copper inside (*laughter*). The impressive strength of the end coil supports is mostly eye-wash (*demonstration*).' Thus Mr. E. T. Norris, racily introducing his paper on *The Mechanical Strength of Power Transformers in Service* on the 27th February. His main theme concerned the soft copper and its progressive yielding under short-circuit fault currents. The axial asymmetry, in particular, grows with each short-circuit, so increasing the severity of the forces of asymmetry.

Early morning fog on the day of the meeting produced considerable traffic delay. But in the Lecture Theatre of The Institution there was no fog in any sense. The author delivered his 30-minute introduction with clarity and wit—a model of presentation. It is difficult to avoid the word 'doyen' in any reference to Mr. Norris: he is surely the elder statesman of the transformer. Even those no longer young remember being reared on his classic papers, and he brings to the subject a lifetime of study devoted to the wilful ways of cardboard, string and copper.

Sir John Hacking, opening the discussion, recalled his co-operation with the author twenty-three years ago in the design of Grid transformers. Mr. Norris had remarked that the axial displacement forces are absent when the windings are perfectly balanced, but that this condition was, alarmingly,

one of unstable equilibrium, like an egg standing on one end. This egg made frequent reappearances in the course of the discussion: Sir John made reference to Christopher Columbus's solution to making the egg stand up. Later speakers had other ideas, such as scrambling it. No one went so far as to suggest that since Mr. Norris had, as it were, 'laid' the egg he might as well hatch it.

Several speakers felt that the first part of the paper made so gloomy an impression that it might be accused of arousing alarm and despondency, but one (an avid student of 'who-dun-its'?) recommended the reader to cheat by scanning the 'happy ending' first. The practical impossibility of dead short-circuit testing came in for comment: yet the number of short-circuit faults in service was a direct measure of transformer life. It was felt that the 25-year service characteristics given by the author all referred to transformers that were 25 years old, and that things were better now.

Mr. M. Waters, himself an author of several reports on electromagnetic forces in transformers, in a series of sprints between blackboard and microphone, elucidated some interesting points of pressures generated by asymmetry. Mr. R. M. Charley wound up the discussion by offering a 350-MVA 3-phase transformer, delivered anywhere in a plain van.

Altogether a stimulating meeting, and a paper that may well become another classic. No one, fortunately, noticed the major electromagnetic 'howler' committed in Mr. Norris's first slide. M. G. S.

'At the Cri'

The Annual Dinner-Dance of the Supply Section was held on the 5th March, in the Grand Hall of the Criterion, under the chairmanship of Mr. P. J. Ryle. The total of members and their ladies present was 327. The attendance was a little lower than that of last year, possibly owing to petrol rationing. However, this did not detract from the success of the function.

Members of the Section were pleased to welcome as their guests the President and Lady Radley, the Chairman of the Radio and Telecommunication Section and Mrs. Williams, the Chairman of the Measurement and Control Section and Mrs. Taylor, and the Chairman of the Utilization Section and Mrs. Gibson.

UTILIZATION SECTION

Three Younger Authors

From time to time it is customary for the Section to devote a meeting to the reading and discussion of short papers by younger members.

At the meeting on the 14th February, three such papers were presented.

The first was *Self-Compensated Alternators*, by P. J. Bhatt, who, in the course of his remarks, pointed out that automatic voltage regulators fall into two categories, namely the functional type, used mainly with machines of small power on account of ease of maintenance and economy of first cost, and the feedback type, which was more suitable for large machines where accuracy of regulation is more important and justifies the extra expense and skilled maintenance required. In the ensuing discussion one speaker made the remark, 'Theory is what nature ignores in practice'.

The second paper, which was presented by D. Mangnall, dealt with *The Metal Rectifier and Its Importance to the Electrical Engineer*. It reviewed the development of the different types of metal rectifier and the various applications to which they had been put. In the discussion it was suggested that probably one of the factors that determined the recent decision to adopt a.c. electrification of British Railways was the development of the junction type of germanium rectifier as an efficient and economical means of converting alternating current to direct current.

The title of the final paper was *The Automatic Factory*, by G. F. Stewart, who said that, as the functions of man in industry were to inspect, to make decisions and to provide control for natural forces, it was necessary, in order to bring about an automatic factory, that the individual items of production work should be evaluated in terms of such functions. He aptly described a rolling mill as 'a glorified mangle'. It was suggested in the discussion that the chemical and oil-processing industries are those which most nearly approach the ideal of continuous automatic working.

All three papers were of a high order of merit and the authors well deserved the enthusiastic support which was given to the vote of thanks. R. H. R.

DISTRICT MEETING AT OXFORD

Fuel in 1984

An informal meeting was held on the evening of the 13th February 1957 at the Oxford District Office of the Southern Electricity Board. The Chairman, Mr. J. L. Taylor, introduced Dr. John Wilks, Fellow of Pembroke College, Oxford, who read a paper on *Fuel and the Future*. Although petrol rationing undoubtedly affected the attendance, forty members and friends were present.

Dr. Wilks produced figures showing that, if the present trend of coal utilization in this country was maintained, it would be virtually impossible to supply the needs of the nation with home-produced fuel by 1980. Alternative available sources of fuel, such as atomic power, would not be sufficiently developed by then to provide the necessary balance. Dr. Wilks pointed out that if more efficient use was made of coal in domestic, railway and colliery applications, substantial savings could be effected.

Dr. Wilks also wondered whether the country could afford the use of electrical power for heating purposes, in view of the large latent heat loss in the transformation from coal to electricity. He considered that the fuel cell, with its direct transformation of fuel to electricity, held great possibilities for the future.

In the lively discussion that followed, Dr. Wilks had a redoubtable opponent in Mr. J. L. Taylor, who established a very strong case for the use of electricity for heating.

Mr. Wise, in proposing the vote of thanks, thought that economics undoubtedly determined how efficiently coal was used, especially in domestic uses. Government subsidy would be needed to enable people to buy efficient fuel-burning apparatus cheaply. D. J.

OVERSEA ATTENDANCE REGISTER

During the period 1st February to 28th February 1957 the following members called at the Institution Building and signed the Attendance Register of Oversea Members:

BUSS, D. A. (Lagos)
COSSER, C. L. (Montreal)
ECKERSLEY T. (Jinja, Uganda)
GAMLEN, D. R. (Accra)
HANSON, J. H., B.SC. (Calcutta)
HARGREAVES, H. R. (Bogota)
HOLIDAY, A. (Kano, Nigeria)
HOLMES, R. H. (Tripoli)
JEFFERSON, B. A. (Singapore)
SHINE, A. T. (Ipoh, Malaya)
WILLIAMS, P. M., B.E. (Somerton, South Australia)

BELFAST

NORTHERN IRELAND CENTRE

Well-Covered Session

In presenting his inaugural address on the 9th October 1956, the Chairman, Mr. Douglas Parry, succeeded in the almost impossible task of pleasing everyone. The modest title of his address, *A Few Remarks About Switchgear*, gave no indication of the wealth of wisdom which he offered on this important subject. While there was something in what he had to say for the experts, his mode of presentation made his 'remarks' intelligible and interesting to all of us. It was a pleasant and uncommon experience to meet an expert with the qualities of an experienced lecturer. Mr. Parry covered his subject very thoroughly indeed, dealing with the basic requirements for arc extinction, the function of a circuit-breaker in an interconnected system, types of circuit-breaker, testing methods and stations and some hints on care and maintenance.

Perhaps the ideal attitude on the part of an Institution member should be that, while specializing in some branch of electrical science (heavy or light, 50 c/s or other frequencies), he should attend meetings regularly and speculate on the whole field of the science and the whole range of frequencies. Arbitrary divisions of the subject may be necessary to define the class of work we do, but no truly great electrical engineer has ever considered himself restricted to one of them. The Papers Committee, therefore, must select papers for a session giving a good coverage of the whole subject. On the lecturers must rest the responsibility of making their subject worthwhile to their own, and interesting to other, brands of expertise. In the first half of this session the Northern Ireland Centre has been fortunate in this respect.

On the 13th November 1956, the late Mr. T. Lawrie's paper, *Highland Water Power—The Developments of the North of Scotland Hydro Electric Board*, was read by Mr. C. L. C. Allan, Chief Electrical and Mechanical Engineer of the North of Scotland Hydro-Electric Board. It was impossible to avoid a feeling of sadness that the author, well known to several of our members, had not lived to see the results of much of his work; but the paper was sympathetically presented and the discussion was a lively and entertaining one. The impact of nuclear fission on the utilization of river energy and the plight of dispossessed crofters were both covered in the discussion.

Sir Hamish MacLaren, Vice-President, visited us on the 11th December and, with tremendous energy, met every member, including Graduates and Students, and every visitor present on that occasion. At the meeting which followed he addressed us with modesty and wit and gave some excellent advice to the younger members based on the theme, 'If I had my life to live over again'. The paper entitled *The Crystal Palace Television Transmitting Station* was then presented by Mr. A. N. Thomas, who explained the difficulties of designing and erecting a television station in the midst of a heavily populated urban area. The discussion indicated that some members (whose personal obsession might be the continuity of electric power supply) were not impressed with the necessity for continuity in visual broadcasting. Others felt it was odd that such a station had to go underground. The author replied in the same happy vein to these questioners and gave considered answers to those with a more serious bent.

An informal paper by one of our Centre members marked the meeting on the 8th January 1957, when Mr. C. Snowdon told us of *New Developments in the Construction and Design of Miniature Electric Motors*. This paper was a revelation, showing us how the adversities of the orthodox designer can become the opportunities of the unorthodox. In fact, it might be said that the paper showed the enormous advantage of possessing an open mind. In the 50 c/s induction motor, 'crawling' is an unmitigated nuisance, but in the higher-frequency motor it can provide the normal running speed—at surprisingly high efficiencies too. The meeting was well

Members and guests at the Centre Chairman's cocktail party before the Annual Dinner and Dance of the Northern Ireland Centre

Sitting, left to right: Mr. W. K. Brasher, Mrs. Brasher, Sir Gordon Radley, Lady Radley, Mrs. Parry, Mr. D. S. Parry, Mrs. Greer, Mr. P. H. Greer, Mrs. Stoupe and Mr. C. M. Stoupe.

attended by both '50c/s' and other engineers, and the discussion was both good and enjoyable.

The first half of the session concluded very happily with the Annual Dinner and Dance in the Grand Central Hotel, Belfast, on the 11th January. A record number of members and guests attended, including the President and Lady Radley, the Lord Mayor and Lady Mayoress of Belfast, and the Secretary and Mrs. Brasher. The dinner was excellent, the speeches light and digestible, and the dance which followed catered for everyone, both ancient and modern, with a merciful absence of rock 'n' roll. D. S. M.

LEICESTER

EAST MIDLAND CENTRE

Faraday Lecture—a Triumph Again

As arranged in the programme for this year's Faraday Lecture, Dr. T. E. Allibone visited Leicester on the 6th February.

His visit was an outstanding success. In the afternoon, by arrangement with local education authorities, 2600 school-children attended the De Montfort Hall to listen to Dr. Allibone, and in the evening an audience of 2500 persons filled the same hall. This achievement of Dr. Allibone in giving the lecture twice in the same day was even more remarkable when it was known that he had spent the previous day confined to his house through illness.

In the afternoon the chair was taken by Mr. D. H. Parry; he was accompanied on the platform by the Deputy Director of Education of Leicestershire, who introduced Dr. Allibone. The vote of thanks was proposed by the corresponding education officer for the City of Leicester. In his address to the school-children, Dr. Allibone remarked that they should consider themselves fortunate to have been born (and to be at school) in a most important era, with the whole of nuclear science about to open out before them. He considered it to be a most interesting future, and it would be their duty to pursue it and to harness the great possibilities that the new age offered, for the benefit and lasting peace of mankind.

At the evening meeting Dr. Haslegrave, Chairman of the East Midland Centre, presided; he called upon the Deputy Mayor of Leicester to introduce Dr. Allibone. Dr. Allibone delivered his lecture in his inimitable manner, and delighted the large audience with his simple presentation of a complicated subject and by his many demonstrations. The vote of thanks was proposed by Mr. J. D. Pierce, Senior Vice-Chairman of the Centre, who also thanked all those who took part in organizing, or assisting Dr. Allibone to present, the Faraday Lecture. D. E. L.

WALES AND WILTSHIRE

WESTERN CENTRE

District Meetings

There is no longer any doubt in the Western Centre that District Meetings are useful, and the phenomenal success achieved in some places is a compliment to those who arrange them. The fact that these meetings are always held 'off the beat' means that a lot of local interest must be aroused, and this calls for good organization.

One such meeting-place seems to be Chippenham. The last meeting there was on the 6th February, when Dr. K. Read gave an informal lecture on *Present Position in Power Rectifier Practice*. Chippenham is of course a centre for the manufacture of rectifiers, and naturally the subject was of great local interest. Dr. Read dealt with all the latest developments in rectifiers and rectifier practice, and a vigorous discussion followed, which had to be curtailed by shortage of time.

Over a hundred attended—a gathering that would be welcome at many a Group meeting. The Chairman of the Western Centre was present, and the arrangements were in the capable hands of Mr. R. W. Maltby, to whom must be given full credit.

CARDIFF GRADUATE AND STUDENT SECTION

It is recognized that for various reasons the Graduate and Student Sections are not as well off numerically as they used to be, and that this is a matter of concern to all those interested in the future welfare of the engineering professions. Nevertheless there is a strong nucleus of energetic and very interested students who deserve better encouragement from both student and senior members.

The outstanding event of the year in the Cardiff Section is the Annual Students' Lecture, followed by the Annual Dinner. This year Dr. M. V. Wilkes lectured on *Digital Computers*, and the appreciation of the audience was apparent in the lively discussion that ensued.

At the dinner which followed, Professor G. H. Rawcliffe, Chairman of the Western Centre, and Dr. Wilkes were the principal guests. The proceedings were most pleasant, and short appropriate speeches were made by both. The Chairman was Mr. R. Denham, who was toasted enthusiastically, his work for the Section being very much commended. D. J. T.

GLASGOW AND EDINBURGH

SCOTTISH CENTRE

In Glasgow on the 28th November 1956 and in Edinburgh on the 19th February 1957, an informal lecture on *A Visit to Russia* was given by Mr. J. S. Pickles and Mr. R. J. Rennie, both of whom had recently visited that country as members of a study group. The lecture was illustrated by a large number of coloured slides mostly made from photographs taken by Mr. Rennie. Amongst the general impressions brought back were the very great friendliness offered to the visitors, the low standard of life of most of the population, the complete lack of knowledge of conditions in western countries, and the unexpectedly large amount of English spoken. On the technical side, although many large and spectacular developments were described, the very poor finish of constructional and other work was stressed, together with the expectation that maintenance problems will very soon reach alarming proportions. The great interest shown in the paper indicated a keen desire on the part of the audience to learn what was being done on the other side of the curtain.

The Annual Joint Dance, organized by the South-East Scotland Sub-Centre and the Edinburgh and East of Scotland Association of the Institution of Civil Engineers, was held at the Charlotte Rooms, Edinburgh, on the 7th February, when 155 members and guests assembled. The correct note was struck at the start by the very humorous dance programmes that had been prepared, and, although kilts were conspicuous by their rarity and the eightsome was reported never to have been so badly danced, the evening was thoroughly enjoyed by all present. E. O. T.